Standing Conference on Teacher Education North and South (SCoTENS)

Final Research Project Report: **Early Number Concepts: Key Vocabulary and Supporting Strategies (STACS/SUC)**

Authors: **Dr. Ann Marie Casserly, Dr. Pamela Moffett, Dr. Bairbre Tiernan**

Introduction

Competence in mathematics is essential in meeting the demands of the workplace and in successful functioning in everyday life. Mathematics is so critical that some have labelled it the "new civil right" (Moses and Cobb, 2001). However, recent research reports have indicated that many children in the North and South of Ireland are failing to reach the expected levels of achievement in mathematics (DENI, 2011; DES, 2011; Eivers et al., 2009; NIAO, 2006; PAC, 2006). A key plan of national strategies north and south of the border (DENI, 2011; DES, 2011) is to promote literacy instruction across all curricular areas, with the expectation that this will improve overall literacy standards, and support children in acquiring disciplinary knowledge in various subject areas. Part of this entails more effective use of oral language to teach subject-specific knowledge and concepts. The need to identify strategies that can be used to improve oral language is vitally important, given that curricular frameworks (CCEA, 2007; NCCA, 1999) outline specific concepts that young children should know.

It is now well established that having a sense of number is a key factor in learning, and subsequently applying, mathematics (Dunphy, 2007). The ability to understand and use the language of number, both spoken and written, is regarded as fundamental to children's learning of number in our culture (Tolchinsky, 2003), and subsequently to the development of their number sense (Dunphy, 2006). Teacher-facilitated 'math talk' in the early years significantly increases children's growth in understanding of mathematical concepts (Klibanoff et al., 2006). Although young children may have a beginning understanding of early number concepts, they often lack the language to communicate their ideas. The teacher plays a significant role in guiding children to make connections, to recognise how their thinking relates to key mathematical number concepts and to make further conjectures and generalisations. Teacher modelling and fostering of mathematical language throughout the day and across various subject areas, allows children to articulate their ideas and communicate their understanding.

The mathematical knowledge teachers possess has a profound impact on what and how they teach (Bobis, 2004; Ball, 1996; Shulman, 1987). Teachers play a key role in helping children develop number sense through creating a learning environment that encourages children to freely explore numbers, operations, and their relationships in meaningful contexts (Siegler and Booth, 2005; McIntosh, 2004; Yang and Reys, 2001). To "empower students to

think mathematically, teachers must first be so empowered" (Ma, 1999, p. 105). Yang et al. (2009) suggest that teachers' lack of number sense as well as their lack of knowledge on how to help children develop it may account for weak performance in number sense. They argue that teachers empowered with knowledge and appreciation for number sense will be more likely to attend to number sense when working with students.

This research project relates to the development of number concepts in the early primary mathematics curriculum with particular reference to Infant classes (Republic of Ireland) and the Foundation Stage (Northern Ireland). The aim of the project was to develop a resource of key vocabulary and teaching and learning strategies to support teachers' planning and teaching in early number. The two main research questions related to this project are as follows: (1) What is the core vocabulary children require to understand, communicate and apply early number concepts?; and (2) What approaches/strategies could assist teachers in their planning and teaching of the language of early number?

This paper documents the development of the resource. The theoretical perspectives underpinning the development of a resource of key vocabulary and teaching and learning strategies for teachers to support their planning and teaching in early number are outlined with regard to achievement in mathematics, number sense, language and mathematics, a socio-cultural perspective on learning and the role of the teacher. A detailed account of the methodology employed is then presented. The latter part of the paper examines the structure of the resource, and the outcomes and benefits of the project in terms of children, teachers, teacher educators and the researchers themselves.

Achievement in mathematics

Although considerable attention has been devoted to mathematics achievement at primary and secondary levels, the foundations for learning mathematics are established much earlier (Clements and Sarama, 2007; McCain and Mustard, 1999). By the time children enter preschool, they demonstrate wide individual differences in their mathematical knowledge, with children from high and middle socioeconomic status (SES) families showing higher levels of mathematics achievement than their lower SES peers (Klibanoff et al., 2006). Such early differences are a matter of some concern since levels of mathematics knowledge at the time children enter school have been shown to predict later achievement (Duncan et al., 2007). Early mathematics skills are an integral part of the young child's overall school readiness skills (Austin et al., 2011). If children can learn to think mathematically and to express their thoughts in mathematical terms during the preschool years, then they are better prepared to learn formal maths concepts upon school entry (Ginsburg, Lee and Boyd, 2008). Children who have higher levels of mathematics skills as preschoolers have been shown to make the most progress in mathematics during the first years of schooling (Starkey and Klein, 2008; Aunola et al., 2004). Austin et al. (2011) argue that neglecting mathematics in the early years might hamper not only children's mathematical development but perhaps their literacy skills as well. In fact, Duncan et al. (2007) found that early mathematics knowledge is a more powerful predictor of later achievement than early language and reading skills. Success in mathematics in the early years is critical. Early differences have long-lasting implications for later school achievement (Klibanoff et al., 2006). Levels of mathematical competency also impact on the need to meet the demand for high levels of mathematical skills to satisfy growing needs for a scientifically and technologically sophisticated workforce (NRC, 2009).

Number sense

The term 'number sense' has been a notable aspect of mathematics education literature over the last twenty years (Howell and Kemp, 2009). Although the importance of number sense in school mathematics has been highlighted by many national reports (NRC, 2009; NCTM, 2000; AEC, 1991; Cockroft, 1982), there is no consensus on a precise definition of the term. Over thirty years ago, Cockcroft (1982) established that a 'feeling for number' is an important mathematical requirement of adult life and used the word 'numerate' to imply the possession of two attributes:

> an 'at-homeness' with numbers and an ability to cope with the practical mathematical demands of everyday life …. an ability to have some appreciation and understanding of information which is presented in mathematical terms, for instance in graphs, charts or tables or by reference to percentage increase or decrease. (Cockcroft, 1982, p. 11).

More recently, 'numeracy' is highlighted in national strategies north and south of Ireland (DES, 2011; DENI, 2011) and is defined as "the ability to use mathematics to solve problems and meet the demands of day-to-day living" (DES, 2011, p. 8) or "the ability to apply appropriate mathematical skills and knowledge in familiar and unfamiliar contexts and in a range of settings throughout life, including the workplace" (DENI, 2011, p. 3).

The introduction of the term 'number sense' was aimed at embracing a range of real-life applications of number as well as balancing the traditional skills-based curricula with approaches which included other aspects of number (Dunphy, 2007). Number sense, in curriculum documents worldwide, refers to "flexibility" and "inventiveness" in calculation and is a reaction to an "overemphasis on computational procedures devoid of thinking" (Anghileri, 2000, p. 2). The National Mathematics Advisory Panel (2008) states that number sense, in its most fundamental form, entails "an ability to immediately identify the numerical value associated with small quantities (e.g., 3 pennies), a facility with basic counting skills, and a proficiency in approximating the magnitudes of small numbers of objects and simple numerical operations" (p.27). A more advanced type of number sense, which must be acquired through formal instruction, necessitates an understanding of place value, of how whole numbers can be composed and decomposed, and of the four basic arithmetical operations (addition, subtraction, multiplication and division); it also requires understanding the commutative, associative and distributive laws and how these can be applied in problem solving (NAP, 2008).

The development of number sense begins long before children begin formal schooling (Anghileri, 2000; McIntosh et al., 1992). McIntosh et al. (1992) identify three core elements in their framework for examining number sense: knowledge of and facility with numbers; knowledge of and facility with operations; and application of this knowledge to computational situations. However, Dunphy (2007) argues that this does not explicitly acknowledge the nature of learning in the early years.

The development of number sense in the early years

Howden's (1989) description of number sense is rooted in children's experiences. She describes children who are developing number sense as those who have "a special feel for numbers, an intuition about how they are related to each other and the word around them" (p. 6). For young children much of their learning will take place in familiar everyday situations, and it is therefore necessary to consider the context as an important aspect of number sense

(Dunphy, 2007). Furthermore, Dunphy (2007) posits that an understanding of the everyday uses of number necessitates an awareness of the various uses of numerals. Such knowledge involves recognising that the same symbol can have different meanings in different situations (Gray, 1997; Greeno, 1991). For example, the number '5' can be used to describe a quantity (such as five candles on a birthday cake), to indicate a position (such as a house number), and to help identify something (such as a bus). According to Greeno (1991), children must learn to recognise the ambiguities of symbols and the need to pay attention to the context or situation in which the symbol is being used. This is important from a socio-cultural perspective, since it acknowledges the context as part of the meaning.

Research has shown, that objects provide concrete ways for children "to give meaning to new knowledge" (Ontario Ministry of Education, 2003, p. 19). Through reflection and discussion on their actions with objects, children link meaning between their representations and the key mathematical concepts (Clements and Sarama, 2009). Although informal mathematics concepts can develop naturally through play and exploration, purposeful social interaction helps to consolidate and extend children's mathematical understanding (Starkey and Klein, 2008; Saxe et al., 1987). It is argued that formal mathematics skills, which are more dependent on instruction by knowledgeable others, best develop through guided discovery and instruction (Austin et al., 2011). In either case, social interaction appears to be an important facilitator in the development of understanding of mathematical concepts.

Greeno's (1991) analysis of number sense explicitly acknowledges the role of the adult, highlighting that "someone who already lives in the environment is an important resource for a newcomer" (p. 197). Dunphy (2007) supports this view since it places greater emphasis on the conditions of learning rather than the 'what' aspect. In her opinion, "the development of their [young children's] number sense needs to be guided by more experienced others and is intrinsically bound up in everyday experiences" (p. 9). Through guided participation in a range of meaningful mathematical experiences, young children become more skilled in understanding and using number.

Disposition is identified as an important aspect of learning mathematics (De Corte et al., 1996). Indeed, Silver (1989, p. 92) contends that disposition towards number activities is "an important, more subtle aspect of number sense" than cognitive competence. Anghileri (2000, p.2) also recognises that "the nurturing of a positive attitude and confidence" is vital in relation to number sense. Children have an active role to play in the development of their own disposition towards number by participating in number-related activities (Dunphy, 2007; Rogoff, 1990).

From a socio-cultural perspective, number sense is best described as a multi-faceted concept that, for the purposes of discussion and analysis, can be described as having a number of different aspects (Silver, 1989). Dunphy (2007) identifies five key characteristics of number sense:

- It is a holistic construct that is difficult to define;
- It is concerned with the development of a wide range of understandings, skills and attitudes about number that extend beyond those generally associated with numeracy and encompass everyday uses;
- It is manifested in the ability to think flexibly about number;
- It is closely related to the development of numeric disposition;
- It is developed as a result of participation in everyday experiences with and about number. (p. 11).

Based on the premise that number sense in young children will be different from that of older learners (Carpenter, 1989), Dunphy (2007) presents the following framework for considering number sense as it relates to four year old children: pleasure and interest in number; understanding of the various purposes of number; quantitative thinking (such as counting, subitizing and estimating; and number relationships); and awareness and understanding of written numerals. The framework is consistent with a socio-cultural perspective on learning.

Language

"Communication can be defined as the exchange of thoughts, information, or feelings. The ability to communicate is at the very heart of early learning and development" (NCCA, 2003, p.29). For most children, language is the dominant form of communication. Language is the ability to communicate with others using a system of symbols which is organised into words and sentences and embraces oral, written, and manual communication, and consists of content (or vocabulary and word meaning), form/syntax (or sounds and sentence structure), and social use of language (NCCA, 2003). According to Vygotsy (1978), concepts are first introduced on an interpersonal level through social interaction and then develop, integrate and expand intrapersonally, as children work to understand and use the concept. On both levels – interpersonally and intrapersonally – language serves a primary role in understanding and mastering what is learned. Language, "the primary cultural tool … is instrumental in restructuring the mind and in forming higher-order, self-regulated thought processes" (Berk and Winsler, 1995, p. 5).

Language also plays a crucial role in helping children to use other cultural tools, including the notational systems of writing and counting (John-Steiner and Mahn, 1996), and is necessary to understand (Jordan et al., 2007) and express (Ginsburg et al., 2008) other kinds of mathematical thinking. Although the notational system for numbers is governed by different rules than those for writing, Austin et al. (2011) argue that the process of developing facility with one cultural tool enables the child to gain better facility with another. Further, it appears that proficiency in language is a key factor in predicting proficiency in mathematics (Austin et al., 2011).

Language and mathematics

Language is fundamental to education because it is the major form of representation of cultural knowledge and the principal medium of teaching. A large part of a child's language experience is verbal and it is through oral language activity that much of his/her learning takes place, both in and out of school (NCCA, 1999). Although studies have shown that specific early language and literacy practices predict later language and reading achievement, much less is known about the nature and frequency of early mathematical interactions, including language, and about the extent to which these interactions affect the development of children's mathematical knowledge. The nature of the relationship between language and mathematical cognition is currently the subject of much debate (Donlan et al., 2007). While some argue that increasing the time spent on mathematics activities could decrease time available to spend on language activities, thus impeding children's development of language, Sarama et al. (2012) argue that this is based on the assumption that mathematics activities have little or no positive effects on language. However, evidence from both educational and psychological research suggests that language and mathematics have co-mutual beneficial

influences. For example, development in both domains appears to follow similar pathways (Sarama et al., 2012). Children generally begin learning number words at the same time as other linguistic labels. By the age of two, most children recognize which words are reserved for numbers and use such words only in appropriate contexts (Fuson, 1988). By the age of six, most children have been exposed to both alphabetic and numerical symbol representations and show signs of being able to segment words into phonemes and partition numbers into component parts (Butterworth, 2005). Further, Sarama et al. (2012) suggest that mathematics learning has the potential to make a unique contribution to children's emerging literacy.

Over the past twenty years, there has been a noticeable shift in curricula, both nationally and internationally, towards engaging children in mathematical thinking. This is evident in the framework for the OECD Programme for International Student Assessment (PISA), where mathematical literacy is described as being "concerned with the ability of students to analyse, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations" (OECD, 2010, p. 14). Likewise, the Northern Ireland Primary Curriculum states:

> As the development of mathematical language is of fundamental importance, talking about work has a high priority in the early years. Through engaging in a wide variety of activities, children should understand mathematical language and then begin to use the language to talk about their work. (CCEA, 2007, p. 23).

The Republic of Ireland's Primary Curriculum states that:

> an important aim of the mathematics programmes is to enable the child to use mathematical language effectively and accurately. This includes the ability to listen, question and discuss as well as to read and record. Expressing mathematical ideas plays an important part in the development of mathematical concepts. (NCCA, 1999, p .12).

Communication and language become the primary means by which mathematics is learned (Lampert and Cobb, 2003). Shiel et al. (2012) identify a number of important consequences if mathematics is to be taught through language. First, developing proficiency in computation skills, devoid of context, is no longer sufficient. Second, there needs to be greater attention on mathematical discussion, with a particular emphasis on children explaining their reasoning as they solve problems set in real-life contexts. Shiel et al. (2012) argue that, in all mathematics lessons, there should be a focus on teaching through discussion, as well as on developing the precise meanings of mathematical terms.

A number of studies show that children's language acquisition is related to the overall amount of language input they receive (Weizman and Snow, 2001; Hart and Risley, 1992; Huttenlocher et al., 1991). Furthermore, the specific lexical terms acquired appear to be sensitive to variations in the amount of input. It therefore seems reasonable to suggest that children's acquisition of mathematical language is also related to the amount of 'math talk' they are exposed to. Klibanoff et al. (2006) contend that the amount of teachers' mathematics-related talk is significantly related to the growth of young children's mathematical knowledge. In other words, teacher input that helps children to learn the language of mathematics will have a positive impact on the development of their mathematics skills. Although acquiring the language of conventional mathematics is only a part of developing understanding in mathematics, it is an important tool for fostering mathematical thinking.

Dunphy (2006) highlights the critical nature of children's interactions with adults as the foundation for their understandings about number. The teacher plays a pivotal role in developing number sense:

> Responding to children's curiosity and interest about numbers, encouraging children to use number as a means of organising and communicating their experiences, modelling of skills related to quantification, and drawing children's attention to the use of numerals in different contexts are also essential pedagogical tasks for the early years' teacher. (Dunphy, 2006, pp. 72-73).

Clearly, this requires an emphasis on talking about number. Furthermore, mathematical activities and discussion should be embedded in meaningful and engaging contexts.

A socio-cultural perspective on learning

Both socio-culturalists and constructivists recognise the importance of individual activity in learning. While constructivists prioritise psychological processes, socio-cultural approaches give priority to the context for learning, placing emphasis on "the conditions for the possibilities for learning" (Cobb and Yackel, 1998, p. 184). According to Rogoff (1998), learning arises from both individual activity and participation in social activity. Rogoff's (1995) view is that individual learning cannot be understood outside of an activity or of the people participating in it. She views learning as the development of mind in socio-cultural context. Children's active participation in an activity is regarded as an important element of the process by which they gain mastery. Rogoff (1990) conceives of children as "apprentices in thinking, active in their efforts to learn from observing and participating with peers and more skilled members of their society" (p. 7). As children engage in culturally valued activities, they become more responsible participants. However, Rogoff (1995) argues that children need to be guided in that participation and she explains the term 'guided participation' as

> The processes and systems of involvement between people as they communicate and co-ordinate efforts while participating in culturally valued activities. This includes not only face-to-face interaction … but also the side-by-side joint participation that is frequent in everyday life and the more distal arrangements of people's activities that do not require co-presence…. The 'guidance' referred to in guided participation refers to observation, as well as hands on involvement in an activity. (Rogoff, 1995, p. 700).

From a socio-cultural stance, learning is seen to be a consequence of collaboration in social activity.

Methodology

The aim of the project was to develop a resource of key vocabulary and teaching and learning strategies for teachers to support their planning and teaching in early number. The proposed research questions included: (1) What is the core vocabulary children require to understand, communicate and apply early number concepts?; and (2) What approaches/strategies could assist teachers in their planning and teaching of the language of early number? Cooper's (2007) model of research synthesis was adapted for the project, namely: step 1, formulating the problem; step 2, searching the literature; step 3, gathering information from literature sources; step 4, evaluating, analysing and integrating the studies; step 5, interpreting the evidence, and step 6, developing the resource. Ethical approval was sought from the Research and Ethics Committees of St. Angela's College and Stranmillis University College at the outset

of the project. The ethical guidelines of both institutions were adhered to throughout the project.

The research methodology utilised in the project was documentary analysis. During this review, books, papers, research reports and policy documents using library and internet sources were consulted and reviewed. The areas of focus emphasised children's development of number, mathematical language and intervention techniques/strategies used to support the development of number and language. The principal focus of the research was on recent national and international research from an Irish, UK and international perspective. The researchers completed a rigorous literature search examining the role of mathematical vocabulary and language in the acquisition of early number. In addition, evidence-based research was reviewed to identify strategies supporting the teaching and learning of early number concepts.

Major Education and Social Science Databases (for example, ARAN-NUI Galway's Institutional Repository; Australian Education Index; British Education Index; Education Research Abstract; ERIC; PsychINFO; SCOPUS-V.4; International Bibliography of the Social Sciences; and the Mathematics Didactics Database; Swetswise; Teacher Reference Centre) were searched using search terms such as mathematical language, language development, development of mathematical language, analysis of number, early number concept, number sense, and so on. Emphasis was given to peer-reviewed sources. Use was also made of national and international statistical surveys of pupils' achievement and progress in mathematics (Eivers et al., 2009; OECD, 2009) and of curriculum documents north and south of the border (CCEA, 2007; NCCA, 1999). These sources provided an extensive basis of documentary evidence and information. Documents were evaluated and critiqued on four criteria, namely: authenticity (genuineness); credibility (accurate, free from bias and errors); representativeness (typical of its type); and meaning (clear and unambiguous) (Denscombe, 2004).

The analysis of documentary evidence was the central and exclusive research method. Content analysis was considered the most appropriate approach in analysing the documents. It was important that appropriate categories and units of analysis, both of which reflect the nature of the documents being analysed and the purpose of the research were identified (Cohen et al., 2004). The studies were reviewed and compared and conclusions drawn concerning the nature of early number concepts and language. The findings of the documentary analysis were used to develop a resource in early number concepts for teachers.

As already stated, this project gathered data from the analysis of secondary sources, namely document analyses. In this sense, no defined research sample was involved in the project. As this research project centred on the development of a resource, there was need for a cohort of teachers to review it. The resource was piloted and reviewed by teachers of infant classes (Republic of Ireland) and the Foundation Stage (Northern Ireland). This process involved teachers familiarising themselves with the resource, implementing the activities and strategies in their classrooms with a focus on facilitating 'math talk', and subsequently critiquing the resource through the use of an evaluation form.

The review process was completed in three stages (February/March 2013; May/June 2013; and September/October 2013) as each section of the resource was completed. Teachers in junior and senior infant classes in the Republic of Ireland and in the Foundation Stage in Northern Ireland were involved in the pilot of sample activities. Teachers in a Special School in Northern Ireland were also involved in the final stages of the project. At each stage of the review process, teachers were provided with a pack which contained an introductory

letter explaining the project, a sample of number activities to pilot, and an evaluation form to complete. The evaluation form evolved to meet the requirements of the particular section being reviewed. It included statements which teachers responded to, using a five-point Likert Scale. Qualitative feedback was also sought regarding the strengths of the resource; possible improvements that could be made in relation to presentation, layout and content; and any other recommendations on further activities. The evaluation forms for the three pilot phases are included in Appendix 1.

The design process of developing the resource included an invitation to tender in both jurisdictions. Three quotations from design companies were considered and the successful recipient demonstrated the ability to develop a teacher friendly, high quality attractive product. Discussions between the researchers and the design company focused on the presentation and layout of content, use of images and accessibility. This resource is included with this submission.

Outcomes

The principal outcome of the project was the production of a teaching and learning resource for teachers in the area of early number concepts with an emphasis on developing associated language. As such, the resource is entitled: ***'Number Talk: a resource to promote understanding and use of early number language'*** (Casserly, Moffett and Tiernan, 2014). It is important to acknowledge that this resource builds on materials already developed for teachers. Based on the analysis of documentary evidence, it was decided to organise the resource into three core areas: Number and Counting; Number Relationships; and Number Operations.

The Number and Counting core focuses on the different uses of number and draws attention to the use of number symbols; the five key principles that underlie counting are highlighted, namely: the one-to-one principle, the stable-order principle, the cardinal principle, the abstraction principle and the order-irrelevance principle (Gelman and Gallistel, 1978); conservation of number is also addressed. Key language in this section includes count, counting words (one, two, three, and so on), zero, forwards, backwards, how many, altogether, total, ordinal language (such as first, second, third, last), odd and even.

The Number Relationships core focuses on comparing, ordering, partitioning and combining numbers. Particular emphasis is placed on the structure of numbers. Instead of counting-by-ones, children are encouraged to use their emerging knowledge of the five and ten structure of numbers, using five and ten as reference points. Activities with spatial arrangements and finger patterns are also provided to support the development of children's arithmetic strategies. Key language in this section includes more than, fewer / less than, the same as, match, pair, after, before, between, bigger, smaller, one more, one less, pattern, same, different, altogether, make, and, partition, set and subset.

Finally, the Number Operations core concentrates on early addition and subtraction. Various structures of each operation are considered. Two main structures of addition are addressed: the aggregation (union of sets) and augmentation (counting on). Five main structures of subtraction are addressed: partitioning (taking away); comparison (difference between); complement of a set; reduction (counting back); and inverse-of-addition. The main emphasis is on partitioning and comparison in the early years. The relationship between addition and subtraction is also highlighted. Key language in this section includes: and, add, plus, how many, altogether, more, take away, left, subtract, minus, difference between,

more, fewer / less, count on, count back, increase, decrease, makes, is, gives, equals, leaves, balances, and matches.

With a view to empowering teachers (Yang et al., 2009), each of the three core sections begins with an overview explaining the underpinning mathematical concepts and principles; a table setting out the key vocabulary and examples of learning experiences associated with the important mathematical ideas outlined; and a table indicating the main areas of focus for each of the activities which follow. This allows teachers to identify the language associated with the particular area of early number that they are teaching and to consider possible meaningful contexts for introducing and reinforcing this language.

Each of the three sections includes a bank of engaging and interactive activities which can be used in small group and / or whole class situations. Each activity is presented according to the following subheadings: mathematical focus, key vocabulary, resources required, activity and possible interactions, taking ideas further, and assessment opportunities. The structured approach to the activities enables children to learn the correct number terminology from the outset. The activities promote the use of meaningful contexts such as play, games, songs, stories and rhymes. The use of real-life objects as learning tools to help children consolidate their understanding and explain their thinking to others is also recommended. Throughout the activities, children are encouraged to make connections between real-life experiences, pictorial representations, symbols and language (Haylock, 2011).

In addition to the three core sections outlined, the resource also includes introductory guidance material on the provision of a number rich environment, ideas for developing number across the setting, and suggestions for promoting home-school links.

Feedback from teachers

Feedback from teachers who piloted the resource activities was extremely positive. Their responses and comments have been summarised under the following headings: Layout and presentation; Content; Impact on teacher practice; General comments and Recommendations for improvement.

Layout and presentation

> *Good structure. Easy to follow.*
>
> *I felt the layout was very clear and the use of italics made it easy to follow in the class context.*
>
> *The layout of the resource is very teacher friendly. If there are children in the class struggling with a particular concept in number then it is easy to source activities from this resource booklet.*
>
> *It has been put together in a way that makes it a workable teacher document and allows teachers to add their own findings.*

Page set-up perhaps all the same (portrait or landscape). Ring-binder – some of the pages came out after so much use.

Would love activities in book form … as I would keep it at hand for daily use.

The presentation in this format is very good. A suggestion would be to produce it in a more colourful format using illustrations. If it were produced on card each idea could be used as a single item and would be more durable.

All of the teachers indicated that they understood the purpose of the resource and agreed that it was user friendly and easy to follow. At the first stage of the pilot, teachers were given the activities in a spiral bound booklet. All of the activities were presented on A4 pages; the introductory section was presented landscape whilst the activities were presented portrait. Some of the suggestions were addressed for subsequent stages in the project.

Content

Excellent planning for key language. Lessons very well structured. Varied activities – well thought out. Active learning evident.

Very useful bank of activities to support my teaching.

Broad range of ideas, questions, etc. Very comprehensive.

Clear and comprehensive resource. Keeps the teacher in touch with the basic activities that are so important.

The key vocabulary sections are very useful. It allows you to identify key words the children should be able to identify and understand.

We will be integrating this into our maths planning.

Activities appropriate for ability and interest level of children.

All activities are exactly pitched and are very consistent with the approach we already use in Foundation Stage classrooms in my school.

Language used is appropriate and nicely laid out.

Strengthening and challenging activities included.

I could not use most of these activities [Number Operations] in early Senior Infants.

I feel that most of the content of the Number Operations section is not yet suitable for children in Sept/Oct of Senior Infants.

All of the suggested activities teachers can alter themselves.

I initially used it with my weaker children but then I changed the numbers (eg., moved from working within 10 to 20/30 with my top group) and carried out some of the activities with enlightening results.

The resource allows for differentiation in each year group.

Teachers indicated that the resource provided excellent material which would serve to support them in their planning for teaching early number. The majority of teachers agreed that the resource was appropriate for children in Infant classes (Republic of Ireland) and the Foundation Stage (Northern Ireland). It is important to note that teachers were invited to pilot the activities at specific stages throughout the project. In some cases, the activities being piloted were too advanced for children as material had not yet been taught. However, teachers did demonstrate an ability to adapt the activities to suit.

Specific feedback was sought regarding content of different sections as detailed below.

Introductory guidance material

Great introduction with focus, vocabulary and learning experiences clearly set out.

The introductory section is an excellent reminder of the appropriate mathematical language we should be using.

I enjoyed reading the Number and Counting introduction. It was very clear and informative.

Super overview of counting activities. I would keep this with daily notebook. It covers all areas of play based learning and great as a check to ensure children have lots of variety when counting.

Teachers agreed that the introductory guidance material for each of the three core sections was a valuable part of the resource and helped to reinforce the key aspects of number and associated vocabulary in the early years.

Activities
The mathematics focus is very clearly outlined. The associated mathematical vocabulary is also very clear. *Key number vocabulary is clearly identified in each lesson plan. Lesson plans are clear and logical. The 'taking ideas further' sections provide opportunities for consolidation work.* *The activities are practical, relevant and engaging.* *Enjoyable and meaningful contexts. Children engaged in real-life and playful contexts. Well-structured lessons with emphasis on developing mathematical language.* *Activities such as these would greatly benefit their understanding of the number concepts.* *Easy to adapt to resources you have available.* *'Rhythmic body counting' essential in Primary 1. A lot of children find co-ordination of movements difficult…. Good to combine with number.* *'Human number line' lesson well thought out. Children loved the opportunities to be actively involved. Children engaged in the experience.* *The 'Fruit bowls' activity is visual and practical. It is exactly the kind of activity that helps the children to talk about and demonstrate their thinking.* *We used 'Number tracks' with number to 20. It was great. Children loved it!! This is an excellent idea.* *'Baker's shop' – the extension activity (putting prices up by counting on 1p) is useful for differentiation.* *'Ten fat sausages' – this activity produced good interaction, discussion and use of mathematical language ("We are learning to count down." / "We are learning to take away.") Another child linked this with component knowledge. When counting one back from four she suggested, "3 and 1 is the same as 4."*

Teachers agreed that the activities were clearly outlined and relevant associated vocabulary was clearly identified. They also welcomed the range of meaningful contexts. Some teachers

also indicated that they had adapted the activities to suit the resources available within their classrooms. Some teachers highlighted particular activities that had worked well.

Promoting Number Across the Setting (Introduction section)

Number Across the Setting is a great 'checklist' to ensure that the teacher is covering all of the everyday activities that complement the discrete maths lesson.

Play activities are clearly sorted into various structured play areas. Lots of ideas to promote number through play activities and classroom discussions.

Lots of very useful play activities in this resource which will match many play topics. A useful tool to encourage teachers to promote number across the Foundation Stage setting.

I really like the Number Across the Setting section. It links in very well with the Aistear programme that we have in place in the Senior Infant classroom.

It provides a good bank of idea questions to ask during play time.

A wide range of interesting and thought provoking activities. The use of role-play and suggested activities of children getting actively involved were great.

Highlights maths is all around us. We use maths everyday often without realising it.

This section of the resource was completed in the final stages of the project. Feedback was highly positive. There has been a greater emphasis on playful learning experiences across the curriculum since the introduction of the Northern Ireland Primary Curriculum (CCEA, 2007) and the Aistear Curriculum Framework (NCCA, 2009). Teachers welcomed the wide range of ideas for promoting number across all aspects of the learning environment.

Impact on teacher practice

Activities thoroughly enjoyed by children. Easy to adapt to resources you have available.

Gives confidence and support for what already goes on in the infant classes.

I had not used puppets with number work before. The children really engaged with the puppet and it encouraged quieter children to use more vocabulary.

The resource provides effective support for developing early vocabulary in teaching mathematics. As there is a bank of ideas there is provision for reinforcing this early vocabulary.

Quality of teaching and learning has been enriched thus improving numeracy standards.

Activities provided the children with valuable and quality learning opportunities.

Teachers observed that children enjoyed participating in the activities and some teachers reported that the resource helped to promote their own confidence. Teachers welcomed the resource because it exposed them to new ideas and strategies. All of the teachers in mainstream classes agreed that children in their classes were better able to engage with the vocabulary of number as a result of using the resource. Some teachers felt that the resource had served to enrich the mathematical learning experiences in their classes.

General comments

I will be trying out the rest of the resources in the next couple of weeks.

Any further activities most welcome.

Excellent resource for any teacher of Foundation Stage.

It is important to build up a good bank of resources to stimulate and have fun lessons.

This is a worthwhile project and a valuable resource. My pupils all enjoyed the activities and were very engaged during each lesson thanks to the variety of multisensory teaching strategies employed. A useful tool to encourage teachers to think carefully about the number language used in the classroom setting.

The resource emphasises maths as a 'talking subject' which is key in Year 1.

Teachers appreciated being invited to critique the resource and demonstrated an enthusiasm in continuing to implement the activities beyond the pilot stage.

Recommendations for improvement

One teacher suggested including activities with Cuisenaire rods as this is an important resource within her Year 1 class. Some teachers also felt that more pictures, diagrams, photographs would help to make the resource more attractive. Teachers did demonstrate a willingness to suggest further ideas and activities would be included within such a resource. These were carefully considered and integrated within the resource where possible.

Conclusion

The aim of this research project was to provide a resource for practitioners to support them in their planning and teaching of early number with a view to developing children's understanding and use of language with regard to early number concepts both in school and in their day-to-day lives. It is envisioned that the resource may also be used by personnel involved in initial teacher education and continuing professional development. The NRC (2009) recommends that number should be emphasised in the development of early mathematics and contends that "improvements in early childhood mathematics education can provide young children with the foundational educational resources that are critical for school success" (p. 331). The NRC (2009) concludes that pre-service preparation and in-service development of teachers in relation to mathematics teaching and learning is essential to effective implementation of early childhood mathematical education. This also links with a prioritised teacher education issue (teaching of numeracy), as identified in the Numeracy Strategies, North and South (DENI, 2011; DES, 2011). Ultimately, the resource aims to facilitate the development of a more numerate society.

The research was made possible by seed funding awarded by the Standing Conference on Teacher Education, North and South (SCoTENS). The research project meets the objectives of the SCoTENS by providing a supportive framework for collaborative research and professional activities in teacher education between St. Angela's College and Stranmillis University College. This project consolidated valuable links from both a professional and inter-institutional perspective and strengthened connections between St. Angela's College and Stranmillis University College. The benefits for the partner institutions have included the development of a collaborative partnership with each other. Frequent meetings between the three researchers involved have resulted in the sharing of knowledge and expertise. The reciprocal nature of this sharing has resulted in the two researchers from St. Angela's College benefiting from the mathematical expertise of the researcher in Stranmillis University College. Conversely, the researcher from Stranmillis gained knowledge in the area of language and special educational needs from her colleagues in St. Angela's. All three researchers enhanced their understanding of the teaching and learning of early number concepts in the two jurisdictions. The developed resource is currently supporting all three researchers in their work with regard to initial teacher training and continuing professional development of teachers. During the course of the meetings, rich mathematical discussion ensued regarding the possibility of further progression of the project. Ultimately, further resources with reference to the other strands of the early mathematics curricula could be developed. Alternatively, the number resource could be developed for all class levels throughout the primary school.

The project adhered to the timelines projected with a PDF of the final resource available on the agreed date. Cognisance was taken of the financial budget at all stages of the project, and considered and careful spending was maintained so as to ensure economic value and transparency. The researchers deem that this project provides good value for money as

it resulted in the development of a practical and timely resource for early years' teachers. A detailed financial report will attest to this.

The resource will be launched in the partner institutions (St. Angela's College and Stranmillis University College) as well as at the SCoTENS Conference (2014). The outcomes of the research project will be disseminated at the following conferences: BCME 8 (Nottingham, 2014), IATSE (Dublin, 2014). It is also intended to present the outcomes at ILSA (Dublin, 2014), NASEN (Belfast) and MEI (Dublin).

Bibliography

Anghileri, J. (2000) *Teaching Number Sense.* London: Continuum.

Aram, D. and Nation, J. (1980) Pre-school language disorders and subsequent academic difficulties. *Journal of Communication Disorders*, 13, pp. 159–198.

Austin, A.M.B., Blevins-Knabe, B., Ota, C., Trowe, T. and Lindauer, S.L.K. (2011) Mediators of preschoolers' early mathematics concepts. *Early Child Development and Care,* 181(9), pp. 1181-1198.

Baroody, A. J. (2004) The developmental bases for early childhood number and operations standards. In: D. H. Clements and J. Sarama (Eds.), *Engaging Young Children in Mathematics: Standards for Early Childhood Mathematics Education* (pp. 173 – 219). Mahwah, NJ: Lawrence Erlbaum Associates.

Baroody, A., Lai, M. L., and Mix, K.S. (2006) The development of young children's early number and operation sense and its implications for early childhood education. In: B. Spodek and O. Saracho (Eds.), *Handbook of Research on the Education of Young Children* (pp. 187-221). Mahwah, NJ: Lawrence Erlbaum Associates.

Baroody, A.J. and Coslick, R.T. (1998) *Fostering Children's Mathematical Power: An Investigative Approach to K-8 Mathematics Instruction*. Mahwah, NJ: Lawrence Erlbaum Associates.

Baroody, A.J. and Kaufman, L.C. (1993) The case of Lee: Assessing and remedying a numerical-writing difficulty. *Teaching Exceptional Children*, 25(3), pp. 14-16.

Benson, A.P. and Baroody, A.J. (2002) *The Case of Blake: Number-Word and Number Development*. Paper presented at the annual meeting of the American Educational Research Association, April, New Orleans, LA.

Berghout, Austin, A.M., Blevins-Knabe, B., Ota, C., Rowe, T., and Knudsen Lindauer, S. L. (2011) Mediators of preschoolers' early mathematics concepts. *Early Child Development and Care,* 181(9), pp. 1181-1198.

Berk, L.E. and Winsler, A. (1995) *Scaffolding Children's Learning: Vygotsky and Early Childhood Education*. Washington, DC: National Association for the Education of Young Children.

Bobis, J. (2004) Number sense and the professional development of teachers. In: A. McIntosh and L. Sparrow (Eds.), *Beyond written computation* (pp. 160-170). Perth, Western Australia: Mathematics, Science & Technology Education Centre, Edith Cowan University.

Carey, S. (2004) Bootstrapping and the origin of concepts. *Daedalus*, 133, pp. 59–68.

Casserly, A.M., Moffett, P. and Tiernan, B. (2013) *Early Number Concepts: Key Vocabulary and Supporting Strategies.* Fermanagh: SCoTENS*.*

Chard, D. (2003) *Vocabulary Strategies for the Mathematics Classroom*. New York: Houghton Mifflin Math.

Clements, D.H. and Sarama, J. (2008) Experimental evaluation of a research-based preschool mathematics curriculum. *American Educational Research Journal*, 45, pp. 443‑494.

Clements, D. H. and Sarama, J. (2007) Effects of a preschool mathematics curriculum: Summative research on the "Building Blocks" Project. *Journal for Research in Mathematics Education*, 38, pp. 136–163.

Clements, D.H. and Sarama, J. (2007) Early childhood mathematics learning. In: F.K. Lester, Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 461-555). New York: Information Age.

Clements, D. H. and Sarama, J. (2009) *Learning and Teaching Early Math: The Learning Trajectories Approach*. New York: Routledge.

Clements, D.H. (1999) Subitizing: What is it? Why teach it? *Teaching Children Mathematics,* 5, pp. 400-405.

Cobb, P. and Yackel, E. (1998) A constructivist perspective on the culture of the mathematics classroom. In: F. Seeger, V. Voigt and U. Waschescio (Eds.), *The Culture of the Mathematics Classroom,* (pp.159-189). Cambridge: Cambridge University Press.

Cockcroft, W.H. (1982) *Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools under the Chairmanship of Dr W. H. Cockcroft.* London: Her Majesty's Stationery Office.

Cohen, L., Manion, L. and Morrison, K (2004) *Research Methods in Education* (5th edn.). London: RoutledgeFalmer.

Cooper, H. (2007) *Evaluating and Interpreting Research Syntheses in Adult Learning and Literacy*. Boston: National College Transition Network, New England Literacy Resource Centre/World Education.

Cowan R., Donlan C., Newton E. J. and Lloyd D. (2005) 'Number skills and knowledge in children with specific language impairment'. *Journal of Educational Psychology*, 97, pp. 732–744.

Darling-Hammond, L. and Ball, D.L. (2000). *Teaching for High Standards: What Policymakers need to know and be able to do*. (CPRE paper, No. JRE-04). Philadelphia: University of Pennsylvania, Consortium for Policy Research in Education.

Davis, E.A. and Miyake, N. (2004) Explorations of scaffolding in complex classroom systems, *Journal of the Learning Sciences,* 13, pp. 265-272.

Dehaene, S. (1997) *The Number Sense: How the Mind Creates Mathematics*. Oxford: Oxford University Press.

Denscombe, M. (2004) *The Good Research Guide for Small-Scale Social Research Projects* (2nd edn.). Berkshire: Open University Press.

Department of Education, Northern Ireland (DENI). (2010). *Initial Teacher Education: approval of programmes* (DE Circular 2010/03).

Department of Education, Northern Ireland (DENI) (2011) *Count Read: Success – A strategy to improve outcomes in literacy and numeracy*. Belfast: DENI.

Department of Education and Skills (DES) (2011) L*iteracy and Numeracy for Learning and Life. The National Strategy to Improve Literacy and Numeracy among Children and Young People 2011-2020*. Dublin: The Stationery Office.

Donlan, C., Cowan. R., Newton, E. J. and Lloyd, D. (2007) The role of language in mathematical development: Evidence from children with specific language impairments. *Cognition,* 103, pp. 23-33.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P. and Japel, C. (2007) School readiness and later achievement. *Developmental Psychology*, 43, pp. 1428–1446.

Dunphy, E. (2007) The primary mathematics curriculum: enhancing its potential for developing young children's number sense in the early years at school. *Irish Educational Studies*, 26(1), pp. 5-25.

Dunphy, E. (2006) The development of young children's number sense through participation in sociocultural activity: Profiles of two children. *European Early Childhood Education Research Journal*, 14, pp. 57-76.

Eivers, E., Close, S., Shiel, G., Millar, D., Clerkin, A., Gilleece, L. and Kiniry, J. (2009) *The 2009 National Assessments of Mathematics and English Reading*. Dublin: Educational Research Centre.

Feigenson, L., Dehaene, S. and Spelke, E. S. (2004) Core systems of number. *Trends in Cognitive Sciences,* 8, pp. 307-314.

Feigenson, L., and Carey, S. (2003) Tracking individuals via object-files: Evidence from infants' manual search. *Developmental Science*, 6, pp. 568−584.

Fuson, K.C. (1988) *Children's Counting and Concept of Number*. New York : Springer - Verlag.

Fuson, K.C. (1992a) Research on learning and teaching addition and subtraction of whole numbers. In: G. Leinhardt, R.T. Putnam, and R.A. Hattrup (Eds.), *The Analysis of Arithmetic for Mathematics Teaching* (pp. 53-187). Hillsdale, NJ: Erlbaum.

Fuson, K.C. (1992b) Research on whole number addition and subtraction. In: D. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 243-275). New York: Macmillan.

Gelman, R. and Gallistel, C.R. (1978) *The Child's Understanding of Number.* Cambridge, MA: Harvard University Press.

Gelman, R. and Butterworth, B. (2005) Number and language: How are they related? *Trends in Cognitive Sciences*, 9, pp. 6–10.

Gersten, R. and Chard, D. (1999) Number sense: Rethinking arithmetic instruction for students with mathematic disabilities. *Journal of Special Education,* 33, pp. 18–28.

Ginsburg, H.P., Lee, J.S. and Boyd, J.S. (2008) Mathematics education for young children: What it is and how to promote it. In: J. Brooks-Gunn (Assoc. Ed.) and L. Sherrod (Ed.), *Social Policy Report*, 22(1), pp. 3–22. Ann Arbor, MI: Society for Research in Child Development.

Gordon, P. (2004) Numerical cognition without words: Evidence from Amazonia. *Science*, 306, pp. 496–499.

Greeno, J. (1991) Number sense as situated knowing in a conceptual domain. *Journal for Research in Mathematics Education,* 22(3), pp. 170-218.

Griffin, S. (2002) The development of math competence in the preschool and early school years: Cognitive foundations and instructional strategies. In: J. Royer (Ed.), *Mathematical Cognition* (pp. 1–32). Greenwich: Information Age Publishing.

Hannula, M. M. (2005) *Spontaneous Focusing on Numerosity in the Development of Early Mathematical Skills*. Turku, Finland: University of Turku.

Hiebert, J., and Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second Handbook of Research on Mathematics teaching and learning* (pp. 371-404). Charlotte, NC: Information Age Publishers.

Hodent, C., Bryant, P. and Houde, O. (2005) Language-specific effects on number computation in toddlers. *Developmental Science*, 8, pp. 420–423.

House of Commons Committee of Public Accounts (PAC) (2006) *Improving Literacy and Numeracy in Schools* (Northern Ireland). London: TSO.

Howell. S. and Kemp, C. (2009) A participatory approach to the identification of measures of number sense in children prior to school entry. *International Journal of Early Years Education*, 17(1), pp. 47-65.

Jeong, Y. and Levine, S.C. (2005*) How do Young Children Represent Numerosity?* Paper presented at the biennial meeting of Society for Research on Child Development, Atlanta, GA.

John-Steiner, V. and Mahn, H. (1996) Sociocultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist*, 31, pp. 191–206.

Jordan, N.C., Kaplan, D., Locuniak, M. N. and Ramineni, C. (2007) Predicting first-grade math achievement from developmental number sense trajectories. *Child Development*, 22, pp. 36–46.

Klibanoff, R., Levine, S., Huttenlocher, J., Vasilyeva, M. and Hedges, L. (2006) Preschool children's mathematical knowledge: The effect of teacher "math talk". *Developmental Psychology*, 42, pp. 59–69.

LaFevre, J., Smith-Chant, B. L., Fast, L., Skwarchuk, S., Sargla, E., Arnup, J.S., Penner-Wilger, M., Bisanz, J. and Kamawar, D. (2006) What counts as knowing? The development of conceptual and procedural knowledge of counting from kindergarten through grade 2. *Journal of Experimental Child Psychology*, 93 (4), pp. 285-303.

Lampert, M. and Cobb, P. (2003) Communication and language. In: J. Kilpatrick, W.G. Martin and D. Schifter (Eds.), *A Research Companion to Principles and Standards for School Mathematics* (pp. 237-249). Reston, VA: National Council of Teachers of Mathematics.

Landerl, K., Bevan, A. and Butterworth, B. (2004) Developmental dyscalculia and basic numerical capacities: A study of 8–9-year-old students. *Cognition*, 93, pp. 99–125.

Levine, S.C., Whealton, L., Suriyakham, Rowe, M.L., Huttenlocher, J. and Gunderson, G.A. (2010) What Counts in the Development of Young Children's Number Knowledge? *Developmental Psychology,* 4, pp. 1309–1319.

Linder, S.M., Powers-Costello, B. and Stegelin, D.A. (2011) Mathematics in Early Childhood: Research-Based Rationale and Practical Strategies. *Early Childhood Education Journal*, 39, pp. 29–37.

Lipton, J.S., and Spelke, E.S. (2006) Preschool children master the logic of number word meanings. *Cognition*, 98 (3), pp. 57-66.

Lonigan, C.J., Schatschneider, C., Westberg, L., with National Early Literacy Panel. (2008) Identification of children's skills and abilities linked to later outcomes in reading, writing, and spelling. In: *Developing Early Literacy: Report of the National Early Literacy Pane*l (pp. 55–106). http://www.nifl.gov (Accessed 24 May 2013).

McCain, M. N.and Mustard, J.F. (1999) *Reversing the Real Brain Drain: Early Years Study, Final Report*. Toronto: Publications Ontario.

McIntosh, A. (2004) Where we are today? In: A. McIntosh and L. Sparrow, (Eds.), *Beyond Written Computation* (pp. 3-14). Perth, Western Australia: Mathematics, Science and Technology Education Centre, Edith Cowan University.

McIntosh, A., Reys, B. and Reys, R. (1992) A proposed framework for examining basic number sense. *For the Learning of Mathematics*, 12(3), pp. 28.

Miller, K.F., Smith, C.M., Zhu, J., and Zhang, H. (1995) Preschool origins of cross-national differences in mathematical competence: The role of number naming systems. *Psychological Science*, 6, pp. 56-60.

National Council for Curriculum and Assessment (NCCA) (1999) *Primary School Curriculum* Dublin: NCCA.

National Council for Curriculum and Assessment (2003) *Towards a Framework for Early Learning: A Consultative Document.* Dublin: NCCA.

National Council for Curriculum and Assessment (2009) *Aistear: The Early Childhood Curriculum Framework*.http://www.ncca.ie/en/Curriculum_and_Assessment/Early_Childhood_and_Primary_Education/Early_Childhood_Education/Aistear_Toolkit/Aistear_and_PSC_audit.pdf (Accessed 12 February 2014).

National Council of Teachers of Mathematics (NCTM) (2000) *NCTM: Draft Guidelines 2000.* Reston, VA, National Council of Teachers of Mathematics.

National Mathematics Advisory Panel (2008) *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, DC: Department of Education.

National Research Council (2009) *Mathematics Learning in Early Childhood: Paths Toward Excellence and Equity.* Committee on Early Childhood Mathematics. Christopher T. Cross, Taniesha A. Woods, and Heidi Schweingruber (Eds.), Centre for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

National Research Council (2001) *Adding It Up: Helping Children Learn Mathematics*. Mathematics Learning Study Committee. J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Centre for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Northern Ireland Audit Office (NIAO) (2006) *Improving Literacy and Numeracy in Schools.* London: TSO.

OECD (2010) *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I)* http://www.oecd.org/pisa/pisaproducts/pisa2009/pisa2009keyfindings.htm. (Accessed 23 May 2013).

O'Neill, D. K., Pearce, M. J. and Pick, J. L. (2004) Preschool children's narratives and performance on the Peabody Individualized Achievement Test – Revised: Evidence of a relation between early narrative and later mathematical ability. *First Language*, 24(2), pp. 149–183.

Ontario Ministry of Education (2003) *Early Math Strategy: The Report of the Expert Panel on Early Math in Ontario*. Toronto: Queen's Printer for Ontario.

Piaget, J. (1941/1952/1965). *The Child's Conception of Number*. New York: Norton. (Original work published 1941).

Pianta, R.C., La Paro, K., and Hamre, B.K. (2007) *Classroom Assessment Scoring System™ (CLASS™).* Baltimore, MD: Paul H. Brookes.

Pica, P., Lemer, C., Izard, V. and Dehaene, S. (2004) Exact and approximate arithmetic in an Amazonian indigene group. *Science*, 306, pp. 499–503.

Rogoff, B. (1990) *Apprenticeship in Thinking: Cognitive Development in Social Context*. New York: Oxford University Press.

Rogoff, B. (1995) Observing sociocultural activity on three planes: participatory appropriation, guided participation and apprenticeship. In: J. Wertsch, P. Del Rio, and A. Alvarez, (Eds.), *Sociocultural Studies of Mind*, (pp. 139-164). New York: Cambridge University Press.

Rogoff, B. (1998) Cognition as a collaborative process. In: W. Damon, D. Kuhn and R. Siegler (Eds.), *Handbook of Child Psychology. Vol. 2: Cognition, Perception and Language* (pp. 679-744). New York: Wiley.

Sarama, J., Langeb, A. A., Clements, D. H. and Wolfe, C. B. (2012) The impacts of an early mathematics curriculum on oral language and literacy. *Early Childhood Research Quarterly,* 27, pp. 489– 502.

Sarama, J. and Clements, D. (2009) Building blocks and cognitive building blocks: Playing to know the world mathematically. *American Journal of Play*, pp. 313–337.

Saxe, G.B., Guberman, S.R. and Gearhart, M. (1987) Social processes in early number development. *Monographs of the Society for Research in Child Development,* 52(2), Serial no. 216.

Shiel, G., Cregan, A, Mc Gough, A. and Archer, P. (2012) *Oral Language Learning in Early Childhood and Primary Education*. Dublin: National Council for Curriculum and Assessment (NCCA).

Shiel, G., Surgenor, P., Close, S. and Millar, D. (2006) *The 2004 National Assessment of Mathematics Achievement*. Dublin: Educational Research Centre.

Shiel, G. and Kelly, D. (1999) *The 1999 National Assessment of Mathematics Achievement.* Dublin: Educational Research Centre, 2001.

Siegler, R.S. and Booth, J. L. (2005) Development of numerical estimation: A review. In: J. I. D. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 197-212). New York: Psychology Press.

Sophian, C. (1998) A developmental perspective on children's counting. In: C. Donlan (Ed.), *The Development of Mathematical Skills*, (pp. 27-46). East Sussex: Psychology Press.

Snowling, M., Adams, J. W., Bishop, D. V. M. and Stothard, S. E. (2001) Educational attainments of school leavers with a preschool history of speech-language impairments. *International Journal of Language & Communication Disorders*, 36, pp. 173–183.

Starkey, P. and Klein, A. (2008) Sociocultural influences on young children's mathematical knowledge. In: O.N. Saracho and B. Spodek (Eds.), *Contemporary Perspectives on Mathematics in Early Childhood Education* (pp. 253–276). Charlotte, NC: Information Age Publishing.

Starkey, P., A. Klein, and A. Wakeley (2004) Enhancing young children's mathematical knowledge through a pre-kindergarten mathematics intervention. *Early Childhood Research Quarterly,* 19, pp. 99–120.

The Teaching Council (2011) *Initial Teacher Education: Criteria and Guidelines for Programme Providers*. Maynooth: Author.

Thomson, S. (2004) Numeracy in the early years: Project Good Start Australian. *Primary Mathematics Classroom*, 9 (4), pp. 14-17.

Vygotsky, L. S. (1978) Interaction between learning and development (M. Lopez-Morillas, Trans.). In: M. Cole, V. John-Steiner, S. Scribner, and E. Souberman (Eds.), *Mind in Society: The Development of Higher Psychological Processes* (pp. 79-91). Cambridge, MA: Harvard University Press.

Weizman, Z.O. and Snow, C.E. (2001) Lexical input as related to children's vocabulary acquisition: Effects of sophisticated exposure and support for meaning. *Developmental Psychology,* 37, pp. 265-279.

Yang, D.C., Reys, R.E. and Reys, B.J. (2009) Number sense strategies used by pre-service teachers in Taiwan. *International Journal of Science and Mathematics Education,* 7(2), pp. 383-403

Appendix 1: Evaluation Forms

Developing Early Counting Vocabulary

Please indicate the year group you used the resource with.

Year group: _____

Based on your experience of using the resource, please indicate the extent to which you agree with the following statements by ticking the appropriate box. Please tick one box only.

SD – Strongly Disagree, **D** – Disagree, **U** – Undecided, **A** – Agree, **SA** – Strongly Agree

	SD	**D**	**U**	**A**	**SA**
1. I understand the purpose of the resource	□	□	□	□	□
2. The introductory section is interesting to read	□	□	□	□	□
3. The resource is clear and easy to follow	□	□	□	□	□
4. The resource is user friendly	□	□	□	□	□
5. The resource provides a useful bank of activities to support my teaching	□	□	□	□	□
6. The counting activities are clearly outlined	□	□	□	□	□
7. The resource highlights the key vocabulary of counting	□	□	□	□	□
8. As a result of using the resource, I have a greater awareness of how to promote the key vocabulary of counting	□	□	□	□	□
9. The resource helped me to facilitate children's discussion of counting	□	□	□	□	□
10. Children enjoyed the counting activities	□	□	□	□	□
11. As a result of using the resource, children in my classroom are better able to engage with the vocabulary of counting	□	□	□	□	□
12. As a result of using the resource, I have observed children in my classroom spontaneously using the vocabulary addressed in this resource	□	□	□	□	□

We would appreciate any additional comments/suggestions in the section below.

Overall, what do you consider to be the strengths of this resource?

Can you suggest any improvements to this resource? For example, you may wish to recommend improvements in relation to content, layout, presentation, etc.

Any other comments

Thank you for taking the time to critique this resource. Your feedback is greatly appreciated.

Dr. Ann Marie Casserly Dr. Pamela Moffett Dr. Bairbre Tiernan

Developing Early Vocabulary in Number Relationships

Please indicate the year group you used the resource with.

Year group: _____

Based on your experience of using the resource, please indicate the extent to which you agree with the following statements by ticking the appropriate box. Please tick one box only.

SD – Strongly Disagree, **D** – Disagree, **U** – Undecided, **A** – Agree, **SA** – Strongly Agree

	SD	**D**	**U**	**A**	**SA**
1. I understand the purpose of the resource	□	□	□	□	□
2. The introductory section is interesting to read	□	□	□	□	□
3. The resource is clear and easy to follow	□	□	□	□	□
4. The resource is user friendly	□	□	□	□	□
5. The resource provides a useful bank of activities to support my teaching	□	□	□	□	□
6. The activities are clearly outlined	□	□	□	□	□
7. The resource highlights the key vocabulary of number relationships	□	□	□	□	□
8. As a result of using the resource, I have a greater awareness of how to promote the key vocabulary of number relationships	□	□	□	□	□
9. The resource helped me to facilitate children's discussion of number relationships	□	□	□	□	□
10. Children enjoyed the activities	□	□	□	□	□
11. As a result of using the resource, children in my classroom are better able to engage with the vocabulary of number relationships	□	□	□	□	□
12. As a result of using the resource, I have observed children in my classroom spontaneously using the vocabulary addressed in this resource	□	□	□	□	□

We would appreciate any additional comments/suggestions in the section below.

Overall, what do you consider to be the strengths of this resource?

Can you recommend any further activities in relation to number relationships?

Can you suggest any improvements to this resource? For example, you may wish to recommend improvements in relation to content, layout, presentation, etc.

Any other comments

You may wish to provide additional feedback on individual activities in the table below.

Activity	Comments

Thank you for taking the time to critique this resource. Your feedback is greatly appreciated.

Dr. Ann Marie Casserly Dr. Pamela Moffett Dr. Bairbre Tiernan

Developing Early Vocabulary in Number Operations

Please indicate the year group you used the resource with.

Year group: _____

Based on your experience of using the resource, please indicate the extent to which you agree with the following statements by ticking the appropriate box. Please tick one box only.

SD – Strongly Disagree, **D** – Disagree, **U** – Undecided, **A** – Agree, **SA** – Strongly Agree

	SD	**D**	**U**	**A**	**SA**
1. I understand the purpose of the resource	□	□	□	□	□
2. The introductory section is interesting to read	□	□	□	□	□
3. The resource is clear and easy to follow	□	□	□	□	□
4. The resource is user friendly	□	□	□	□	□
5. The resource provides a useful bank of activities to support my teaching	□	□	□	□	□
6. The activities are clearly outlined	□	□	□	□	□
7. The resource highlights the key vocabulary of addition and subtraction	□	□	□	□	□
8. As a result of using the resource, I have a greater awareness of how to promote the key vocabulary of addition and subtraction	□	□	□	□	□
9. The resource helped me to facilitate children's discussion of addition and subtraction	□	□	□	□	□
10. Children enjoyed the activities	□	□	□	□	□
11. As a result of using the resource, children in my classroom are better able to engage with the vocabulary of addition and subtraction	□	□	□	□	□
12. As a result of using the resource, I have observed children in my classroom spontaneously using the vocabulary addressed in this resource	□	□	□	□	□

We would appreciate any additional comments/suggestions in the section below.

Overall, what do you consider to be the strengths of this resource?

Can you recommend any further activities in relation to addition and subtraction?

Can you suggest any improvements to this resource? For example, you may wish to recommend improvements in relation to content, layout, presentation, etc.

Any other comments

You may wish to provide additional feedback on individual activities in the table below.

Activity	Comments

Activity	Comments

Thank you for taking the time to critique this resource. Your feedback is greatly appreciated.

Dr. Ann Marie Casserly Dr. Pamela Moffett Dr. Bairbre Tiernan

Promoting Number across the setting

Please indicate the year group you used the resource with. **Year group**: _____

Based on your experience of using the resource, please indicate the extent to which you agree with the following statements by ticking the appropriate box. Please tick one box only.

SD – Strongly Disagree, **D** – Disagree, **U** – Undecided, **A** – Agree, **SA** – Strongly Agree

	SD	**D**	**U**	**A**	**SA**
1. The resource is user friendly	□	□	□	□	□
2. The ideas are clearly presented	□	□	□	□	□
3. The resource provides a useful bank of activities to support my teaching	□	□	□	□	□
4. The ideas are appropriate for children in Foundation Stage	□	□	□	□	□
5. As a result of using the resource, I have a greater awareness of how to promote number across a range of learning contexts	□	□	□	□	□

We would appreciate any additional comments/suggestions in the section below.

Overall, what do you consider to be the strengths of this resource?

Can you suggest any improvements to this resource? For example, you may wish to recommend improvements in relation to content, layout, presentation, etc.

Any other comments

There may be some further ideas which you wish to recommend for inclusion. Please feel free to note these below.

Learning context	Other ideas

Thank you for taking the time to critique this resource. Your feedback is greatly appreciated.

Dr. Ann Marie Casserly Dr. Pamela Moffett Dr. Bairbre Tiernan