Chapter 3
Assessing Young Children's Mathematical Understanding: Opportunities and Expectations at the Transition to School

Barbara Clarke

Abstract One-to-one interviews have been used extensively in Australia by both researchers and teachers to assess young children's mathematical understanding. This chapter discusses the use of a one-to-one task based interview developed as part of the Early Numeracy Research Project. The First Year of School Mathematics Interview component has been used in a range of research contexts, both prior to school and in the early years. A recent study, using the interview with children with Down syndrome where the interview was presented in a more flexible manner, raises important questions regarding its use both in research and practice. The opportunities and expectations during the transition to school and how these may be enhanced by the use of one-to-one assessment interviews is also discussed.

3.1 Introduction

When assessing children as teachers or researchers, we have access to their mathematical understanding through watching, listening or their documentary productions. These can be produced through a range of techniques or provocations. Any insights into the mathematical understanding or thinking of young children which emerge are a product of these provocations and the interpretation of the educator.

Assessment in mathematics has long been associated with pen and paper methods with the traditional mathematics test dominating assessment practices in school including the early years (Clements and Ellerton 1995). However, observational techniques have traditionally been the main focus of assessment of individual children in early childhood settings and these have been general in nature with an emphasis on cognitive, social-emotional, physical and language development (Fleer and Quinones 2013). There is an increasing focus on assessment within curriculum disciplines in early childhood with the implementation of more specific articulation of curriculum requirements.

B. Clarke (✉)
Monash University, Melbourne, Australia
e-mail: barbara.clarke@monash.edu

B. Perry et al. (eds.), *Mathematics and Transition to School,* Early Mathematics Learning and Development, DOI 10.1007/978-981-287-215-9_3

In the transition to school, the differences in forms and roles of assessment have potential to impact children, educators and other caregivers. External forms of assessment including those that are used to evaluate students for special programs or interventions are often given during this transition period. Specialist practitioners provide data on individuals that are often used to determine funding for care and support, particularly in school systems where such information provides a measure of need. While such data are valued for their reliability, they may be of limited use to the classroom teacher or educator. In addition, parents are often expected or required to engage in decision-making based on the results of assessment. Difficulties in this process can lead to increased disadvantage for those who are less informed or empowered to advocate.

There is tension between the different roles of assessment and the form of assessment used should reflect the purposes of its use. However in the busy life of an educator it is necessary to make decisions based on manageability as well as meaningfulness.

Sometimes, politicians and other educational policy makers seem to believe that it is the act of assessment that will lead to improved learning, when in fact it is the action that follows, using the information gained from the assessment that is potentially most powerful (Clarke 1989). For the educator, the information needs to be valid and provide potential for action.

In this chapter, experiences of the use of one-to-one task based interviews as a tool for gaining valid insights into the mathematical thinking of young children in the transition to school will be shared.

3.2 Task-Based Interviews as an Assessment Tool for Mathematics

The power of a one-to-one, task-based interview as a tool for both teachers and researchers to notice young children's mathematics has been well documented (Bobis et al. 2005; Clarke et al. 2011; Ginsburg 2009). Different approaches to the conduct of an interview can provide different insights into children's mathematics learning and thinking. They can show what children can do through well designed tasks and questions. Of course, researching and understanding young children's mathematical thinking is challenging, as much of what we want to know are cognitive processes or mental strategies.

Following the work of Piaget, clinical interviews have been used for many years in mathematics education research (Ginsburg et al. 1998). Typically, such research had been conducted with relatively small numbers of children, and the results not always communicated well to the teaching profession. However, the late 1990s, in Australia and New Zealand, saw the development and use of research-based one-to-one, task-based interviews with large numbers of children, as a professional tool for teachers of mathematics (Bobis et al. 2005). The interview that was developed as part of the Early Numeracy Research Project (ENRP) was typical of these.

3.3 The Early Numeracy Research Project

The ENRP was conducted from 1999 to 2001 in 35 project ('trial') schools and 35 control ('reference') schools, and involved 353 teachers and over 11,000 students aged 5–8 years in the first 3 years of school, in Victoria, Australia (Clarke et al. 2002). There were three main components to the project: a framework of research-based growth points as a means for understanding young children's mathematical thinking; a one-to-one assessment interview used by all teachers at the beginning and end of the school year as a tool for assessing knowledge and strategies for particular individuals and groups; and a multi-level professional development program geared towards developing further such thinking.

The interview was structured with specific instructions for administration and recording. It allowed for more conversation and recording of varied strategies than more formal psychological assessment protocols. Such strict protocols are arguably more reliable for comparison but do not provide the same richness of data for either the researcher or the teacher.

Of course a structured interview can provide surprising insights. A favourite anecdote from the interviews for the ENRP came from a teacher and related to the "draw a clock" task, in which the children were instructed to simply "draw a clock." The child's clock was then used to initiate a discussion of their understanding of how time and clocks work.

> I asked the child "What are the numbers on the clock doing?" The child looked strangely at me and said "the numbers are doing nothing; they are waiting for the arrows to come around. Don't you know that? Are you stupid or something?" (ENRP teacher)

3.3.1 A Research-Based Framework of "Growth Points"

To underpin the task-based interview, it was decided to create a framework of key 'growth points' in mathematics learning. Students' movement through growth points could then be tracked over time. The project team studied available research on key 'stages' or 'levels' in young children's mathematics learning (Carpenter and Moser 1984; Fuson 1992; Mulligan and Mitchelmore 1996; Wright 1998), as well as frameworks developed by other authors and groups.

Within each mathematical domain, growth points were stated with brief descriptors in each case. There are typically five or six growth points in each domain. To illustrate the notion of a growth point, consider the child who is asked to find the total of two collections of objects (with nine objects screened and another four objects). Many young children 'count-all' to find the total ("1, 2, 3, …, 11, 12, 13"), even though they are aware that there are nine objects in one set and four in the other. Other children realise that by starting at nine and counting on ("10, 11, 12, 13"), they can solve the problem in an easier way. Counting All and Counting On are therefore two important growth points in children's developing understanding of addition.

1. Count-all (two collections)
   Counts all to find the total of two collections.
2. Count-on
   Counts on from one number to find the total of two collections
3. Count-back/count-down-to/count-up-from
   Given a subtraction situation, chooses appropriately from strategies including count-back, count-down-to and count-up-from.
4. Basic strategies (doubles, commutativity, adding 10, tens facts, other known facts)
   Given an addition or subtraction problem, strategies such as doubles, commutativity, adding 10, tens facts, and other known facts are evident.
5. Derived strategies (near doubles, adding 9, build to next ten, fact families, intuitive strategies)
   Given an addition or subtraction problem, strategies such as near doubles, adding 9, build to next ten, fact families and intuitive strategies are evident.
6. Extending and applying addition and subtraction using basic, derived and intuitive strategies
   Given a range of tasks (including multi-digit numbers), can solve them mentally, using the appropriate strategies and a clear understanding of key concepts.

Fig. 3.1 ENRP growth points for the domain of addition and subtraction strategies

The six growth points for the domain of addition and subtraction strategies are shown in Fig. 3.1.

These growth points informed the creation of assessment items, and the recording, scoring and subsequent analysis.

We do not claim that all growth points are passed by every student. For example, growth point 3 involves 'count-back', 'count-down-to; and 'count-up-from' in subtraction situations, as appropriate. There appears to be a number of children who view a subtraction situation (say, 12 − 9) as "what do I need to add to 9 to give 12?" and do not appear to use one of those three strategies in such contexts. This student is using a 'fact family', one of what we call 'derived strategies' (see Growth Point 5).

The growth points should not be regarded as necessarily discrete. As with Wright's (1998) framework, the extent of the overlap is likely to vary widely across young children, and "it is insufficient to think that all children's early arithmetical knowledge develops along a common developmental path" (p. 702).

3.3.2 Early Numeracy Research Project Interview

A one-to-one interview in Number, Measurement and Geometry was developed to be used with every child in grades K-2 in ENRP schools at the beginning and end

18) Counting on

a) Please get four green teddies for me.
Place 9 green teddies on the table

b) I have nine green teddies here *(show the child the nine teddies, and then screen the nine teddies with the ice-cream lid).*
That's nine teddies hiding here and four teddies here *(point to the groups).*

c) Tell me how many teddies we have altogether... Please explain how you worked it out.

d) *(if unsuccessful, remove the lid).* Please tell me how many there are altogether.

Fig. 3.2 An excerpt from the addition and subtraction interview questions

of the school year. The interview was expected to take around 40 min per child. The disadvantages of pen and paper tests have been well established by Clements and Ellerton (1995) and others, and these disadvantages are particularly evident with young children, where reading issues are of great significance. The face-to-face interview was an appropriate response to these concerns. Many writers have commented on the power of the one-to-one assessment interview as providing powerful insights into student thinking (Schorr 2001).

Although the full text of the ENRP interview involved around 60 tasks (with several sub-tasks in many cases), no child moved through all of these. The path was specified, in accordance with a student's response to each task. Figure 3.2 shows a question, involving little plastic teddy bears, from the section on Addition and Subtraction Strategies. Words in italics are instructions to the interviewer. In normal type are the words the interviewer uses with the child.

Question 18 provided information on whether the child was able to count-on or use a known fact, needs to count-all, or was unable to find the total by any means. The aim in the interview was to gather information on the most powerful strategies that a child accesses in a particular domain. However, depending upon the context and the complexity of the numbers in a given task, a child (or an adult) may use a less powerful strategy than they actually possess, as the simpler strategy may "do the job" adequately in that situation.

Of particular interest when considering young children and the transition is the First Year of School Mathematics Interview (FYSMI), a component of the larger ENRP interview. Details of the FYSMI including data from a large sample of children are reported in Clarke et al. (2006). The teachers in a specialist school for children with specific learning needs within the ENRP found it to be a very valuable tool that was easily used and interpreted in their context (see Clarke and Faragher 2004). The FYSMI has also been used by researchers in preschool settings with considerable levels of engagement (Clarke and Robbins 2004). It also enabled comparison with the larger ENRP data set.

A further feature of the ENRP one-to-one task based interview was that the children in the early years had the opportunity to go beyond the mathematics dictated by

the curriculum and there was very limited ceiling effect. It provided both teachers and researchers with unexpected insights as illustrated by the following teacher quote:

> I have to admit I was really surprised when I did the testing on them, at how much two or three of them knew, they knew far more than I realised. A couple of them are being held back because they still can't do the counting, one, two, three, they go wrong. But when we go beyond that it's just amazing how much understanding they've got. I was just blown away by a couple of the results, I really was. (Special school teacher interview, as reported in Clarke and Faragher 2004)

While instruments such as the ENRP interview including the FYSMI provide opportunities for individual children's thinking and strategies to be evidenced, they generally assume a traditional trajectory of mathematics learning and may limit options. They evidence a 'moment in time' rather than a definitive assessment of an individual child's mathematical understanding. This is particularly relevant and possibly limiting when interviewing children with specific learning difficulties. In a recent project that attempted to map the mathematical development of young children with Down syndrome (Faragher et al. 2008; Faragher and Clarke 2014), the ENRP interview was adapted and a slightly different approach taken to its application.

Literature indicated that children with Down syndrome interviewed in unfamiliar contexts by people they did not know reduced performance on literacy tasks (Brown and Semple 1970}. Therefore, we interviewed children with Down syndrome in their home or school, in the presence of their parents (or teacher) who watched from behind the child. The adults were invited to comment on the performance of the child, either by taking notes during the interview, or in a discussion following the interview. The interviews were videotaped and the 'semi-structured' approach that was used is discussed in the next section.

3.4 One-to-One Mathematics Interviews with Young Children with Down Syndrome

With a limited research base, methods to chart the mathematical learning of children with Down syndrome are still developing. The choice of task-based, one-to-one interviews was appropriate. The ENRP interview (Clarke et al. 2002) and Extending Mathematical Understanding (EMU) interview (Gervasoni 2004) were used as the basis of an interview with children with Down syndrome. While these instruments were already demonstrably effective, necessary modification, trial and development was undertaken.

In the Down syndrome project, the interview was implemented in a more flexible form than in the ENRP and associated project to ensure maximum opportunities for individual children to show what they knew and could do rather than as a protocol driven instrument. Tasks were first asked in the same form of wording

as the original instrument but follow-up questioning, instructions or guidance were provided at the discretion of the interviewer. This allowed the interviewer to follow up on responses from the child, to double back to earlier tasks, to ask a similar task in a different way and to add tasks, such as counting stickers that had been given as rewards during an interview. In order to do this, the interviewer needed to know the purpose behind the interview questions as well as be able to make preliminary judgments about what was being observed in the interview while it was in progress. The interviews were video-taped to allow more detailed analysis.

Sometimes, children with Down syndrome exhibit behaviours that hinder the assessment of their mathematical understanding. In the case of one child, Gina, giving an answer "one" seemed to be 'avoidance' behaviour, a well-established aspect of behaviour in children with Down syndrome (Wishart 1996). This is a learned (albeit potentially unhelpful) behaviour, and not in any sense misbehaviour. There were seven occasions during the interview when Gina gave an answer "one". On only one occasion was this an appropriate response. It appeared from the analysis of the video that it was her 'default' response. It would seem to be an attempt to disengage with the question, perhaps to effectively avoid thinking about the question, or maybe to provide a response when knowing what to do was unclear. A particular example is quite enlightening:

> Gina was presented with some dot cards and numeral cards and asked to find the number to match the dots. She did not show evidence of matching but pointed to the numeral 3 and said "three." The interviewer used this as a cue to ask if she knew any other numbers. During this sequence, the interviewer picked up the card with the numeral 4 and asked Gina what number it was. Gina responded quickly by saying "one" and then said "four" quietly. It was as if "one" was her standard answer and then she realised that she actually could read the numeral.

Gina was an engaging child but struggled with much of the interview. She was one of the youngest of the children that was interviewed. However, the flexible approach gave greater insights into her thinking than would have been the case following the script per se. A more traditional protocol driven assessment interview where the first answer is used or where restatement or adaption by the interviewer is not permitted would have limited what was found. Of course, differences in methodology are generally due to different purposes, but for this project we wanted to expand the opportunities for the children to show what they knew and could do.

A further example was when one of the questions from the FYSMI that focused on location language was asked. The original task asked children to place a small plastic teddy in a specified position relative to another teddy. Maggie was asked to place a green teddy behind the blue teddy that was in front of her on the table. She did not do this so the interviewer got out of her seat, moved over to the clear space with Maggie and asked her to stand behind her. Maggie did this successfully, showing some understanding of the concept 'behind'. This additional task became a feature of future interviews within the Down syndrome project providing additional information on the mathematical understanding of the children.

3.4.1 Strategies for Dealing with Avoidant Behaviour

A major reason for the use of the semi-structured approach to the task-based interview was in response to the behaviour of the children. As previously mentioned, avoidant behaviour has been extensively documented even in very young children with Down syndrome. Therefore, we were not surprised (though we were certainly entertained!) by the many instances where children were using strategies to avoid attempting the tasks such as changing the tasks, playing with the equipment, using behaviours to distract the interviewer (burping, being 'cute,' changing the subject) and refusing to participate. It is important to note that children used avoidant strategies even when they were able to do the tasks. Our interview protocol and flexible technique allowed us to work around these antics to gather data we could trust. Some studies on mathematics performance by children with Down syndrome give a more pessimistic view than the experiences of parents and teachers would suggest (Abdelhameed and Porter 2006). The discrepancy may be due to the use of research methods which are unable to take account of the avoidant behaviours and therefore limit opportunities.

Modification to the interview became necessary for some participants when it appeared that the presentation of the tasks themselves was distracting. The standard interview protocol makes use of objects such as plastic teddy bears with the deliberate purpose of engaging participants. For some of our children, though, these objects seemed to be a distraction. Some children needed to arrange all the teddies to be facing the same way, but took so much time that they forgot what they needed to do for the task. Others engaged in the story of the teddies going to the beach and lying on beach towels (as a context for division), to the point of missing the mathematics. It could be that the children were glad of an alternative task to pursue or it could be that they were genuinely distracted from the mathematics. In either case, however, it became clear that small blocks could be used instead, making explicit the mathematics required.

Mary was one of the older children interviewed and confidently worked on the first few tasks in the interview. She was then asked to take five blue teddies from a mixed collection which she did successfully. Next the interviewer spread the teddies out and asked how many there were. Mary counted again, successfully. The intent was to see if she would identify the quantity *without* counting and arguably evidence conservation of number (see Clarke et al. 2006, for discussion of the difficulties in interpreting this task). The interviewer again repeated the process and Mary again counted. While we would have expected that she could conserve number and understand that the count indicated the numerosity of the set, this task had not provided the necessary evidence.

As the interviewer packed up the teddies she had the blue teddies in a group under her hand. She then asked Mary how many there were and Mary quickly answered "5." She was clearly demonstrating understanding of the cardinality of the set and conservation though not in response to the question intended to elicit this knowledge, but rather from an incidental question. This interaction again illustrates

the challenges of more protocol driven interviews with the behavioural practices of children with Down syndrome and the value of flexibility in the hands of a knowledgeable researcher in providing insights into mathematical understanding and thinking.

The interviewer needs to be flexible and highly skilled in understanding the mathematics underlying the interview questions in order to probe appropriately and provide valid data on individual understanding. This approach provided greater insight into the mathematical thinking and processing of the children with Down syndrome we were studying.

3.5 Interviewing as Enhancing Teachers' Knowledge

One of the key findings of the ENRP was the value of the interview for enhancing teachers' knowledge (Clarke et al. 2011). Along with the growth points, the interview provided teachers with insights into children's mathematical thinking and a way of describing what they were seeing and hearing when children are engaged in mathematics. They evidenced improved questioning techniques including the opportunity to see the benefits of increased wait time. It provided "a clearly evidence-based understanding of student thinking in mathematics and what students know and can do" (p. 907).

Portions of the broader ENRP interview have been used by student teachers in a range of contexts. In a study to investigate the effectiveness of using the task based interview to build pre-service teachers' understanding of what children know and can do in the early years of school, McDonough et al. (2002) found that the use of the interview enhanced the knowledge and skills of pre-service teachers in the following ways:

- Pre-service teachers are more aware of the kinds of strategies that children use, including their variety and level of sophistication.
- Pre-service teachers have seen the power of giving children one-to-one attention and time, without the distraction and influence of their peers.
- The interview provides a model of the kinds of questions and tasks that are powerful in eliciting children's understandings.
- The interview and subsequent discussion stimulate pre-service teachers to reflect on appropriate classroom experiences for young mathematics learners. (p. 223)

Interviews have been conducted by future teachers as part of their teaching experience in the context of preschools as well as the early years of school. These have provided insights into the mathematical thinking of young children as well as a shared language for describing and discussing this thinking. Carpenter and Lehrer (1999) highlighted the importance of this linking:

> Knowledge of mathematics must also be linked to knowledge of students' thinking, so that teachers have conceptions of typical trajectories of student learning and can use this knowledge to recognize landmarks of understanding in individuals. (p. 31)

Bobis and Gould (1999), reporting on the Count Me In Too (CMIT) project in New South Wales, also found that the provision of a research-based learning framework enhanced teachers' knowledge of how children learn mathematics. In a major project in New Zealand, the National Numeracy Project, the learning framework gave teachers "direction for responding effectively to children's learning needs" (Higgins et al. 2003, p. 166). It is not the interview on its own but the interpretation and possibilities for learning that such assessment creates that are particularly powerful.

3.6 Implications for Transition

In addition to being a tool for researchers, this work has highlighted the value of a task-based one-to-one assessment interview for educators in the early years of school. As previously discussed, we can assess children through watching, listening or interpreting documentation. Is the interview just about listening? It is more than just listening, as it is the form of the questions—the provocations that are linked to important mathematical ideas, which provide a direction for subsequent questioning as well as future planning. There is structure based on the research on children's mathematics learning to enable purposeful assessment. The interview can provide 'eyes and ears' for the educator to see, hear and interpret the mathematical thinking of the child. Their experience with the interview means that they know what to look for.

For many early years' teachers, the role of the interviewer was novel, but this brought challenges. They were less the teacher and more the observer and in some cases this was a struggle. In the early stages of the ENRP when the child was not successful a teacher would comment, "but they could do it yesterday." Or they would claim that the child would have been successful if the question was asked in a different way. It was a shift from success being measured by a correct answer to a deeper focus on finding out what the child really knew, the strategies they used and the 'edges' of their learning.

Such an interview provides a range of opportunities for the children that are important as they transition to the generally more formal school setting. It provides a balance between structure and openness. Not structure for its own sake, but to enable a focus on the important mathematics. It needs to provide opportunities for extending and surprising the interviewer, whether in the role of educator or researcher. It can also provide an opportunity to challenge the expectations of the teacher.

3.6.1 Expectations of Children

From very early in the ENRP, teachers observed what for many were unexpected levels of mathematical understanding among their children. The first set of interviews provided teachers with information about their individual children that had not been previously obtainable, and initially many were surprised by what their

children knew. Several quotes from ENRP teachers capture the spirit of many teachers' comments, as they reflected on highlights and surprises that emerged from the first set of interviews.

> My greatest surprise was that most children performed significantly better than I anticipated. Their thinking skills and strategies were more sophisticated than I expected.
> Working with a gifted five year-old who actually worked out the answers quicker than I did. Reading 24 746 154 on the calculator. Amazing!

It should be noted however, that the raising of expectations was not across the board. There were several areas where teachers were surprised with the difficulty that many children appeared to have on particular tasks:

> Many children had difficulty with the task involving sharing 12 teddies between 4 teddy mats, and with the tasks relating to abstracting multiplication.

> Quite a few children were able to read and write two- and three-digit numbers, but were unable to order one-digit numbers.

> Reading clocks was more difficult for children than many teachers expected, given its emphasis in their programs.

Overall, the expectations were more realistic and linked directly to the children rather than the teaching and curriculum expectations. The following quote from a teacher at the end of the project illustrates this:

> I expect more and I extend horizons more. I'm not as structured in my approach and I realise that there might be more than one way of solving a problem. I am interested in how children 'think'.

The importance of the interview to enable children to show what they know is evident in this quote:

> Four years ago this is what we taught preps [first year of school] and that's what I taught and that's what I tested so at the end of the year I could say 'that child can do that' but I wouldn't be able to tell you what else he could do.

The interview also clearly showed those aspects with which the children were still struggling, but not in a judgmental or comparative approach but intended as joint exploration of their thinking. The role of the interviewer whether an educator or researcher was to elicit mathematical thinking—to find the 'edge' of their current understanding, some might argue their zone of proximal development.

In the Australian state of Victoria, an on-line adapted version of the ENRP interview is used extensively in the early years. It is time consuming but provides an opportunity for young children to show what they know and can do to their teachers in a comfortable and safe environment.

We are extending our work with children with Down syndrome to focus on teachers in inclusive settings in primary schools and plan to produce, trial and refine a version of the interview that enables teachers to develop a record of the mathematical thinking of the child with greater flexibility and an on-going record that builds over time. One of the challenges is the challenge of gathering the fine-grained information that might be useful in the context of children with special needs as well as early indicators of mathematical understanding in content other than number.

3.7 Concluding Comments

Structured task-based one-to-one interviews are an important methodology for researchers to notice the mathematics of young children. Highly structured protocols provide reliable comparisons but limit the opportunities for children to evidence the richness of their mathematical understanding. Structured interview protocols that are designed to elicit different strategies, encourage conversations and highlight children's thinking (such as the ENRP interview) provide greater insights about individual children. A more flexible approach in the form of semi-structured interviews has provided richer and more valid data for children with Down syndrome and has much potential for researching the mathematics of young children in general. A knowledgeable interviewer is required for this method to be effective. It requires sophisticated knowledge of the mathematical development of young children as well as the skills to engage the children, to intervene or stay silent, to persist or know when to move on.

In the context of the early years of schooling, a structured interview given by an informed educator is an important tool in their assessment repertoire. As we move from the largely observational strategies of early childhood to the paper-based assessments of the school system, the semi-structured, one-to-one task based interview provides a transition in form that is accessible to the children and responsive to the individual. For the school teacher, at the beginning of the school year, the interview can provide important insights into the mathematical thinking of the children in their class enabling opportunities for more focused and appropriate teaching.

One of the challenges in the transition for educators is the identification and articulation of the mathematics through having a common understanding and language. In the early years of school, there has been a shift to the valuing of the strategies rather than the specific answer. For example, in the past we may have recorded if a child could successfully add 4 and 5, with value placed on quick recall of this calculation. The shift has been to the strategies, so that a child who can tell you that $4+5$ is 9 because they know that $4+4$ is 8 and this is one more, is evidencing a quality of mathematical thinking that is likely to be built on constructively. The previous practice often developed a rote approach to teaching and an emphasis of the answer rather than the thinking. However change takes time and such limited approaches are still emphasised in many school settings. Is there a similar emphasis in preschools? Are we able to link the expectations of curriculum documents across the transition in ways that will enable the effective development and use of the assessment tools to which our children are entitled?

In assessment, providing opportunities and tools for the child to demonstrate what they know and can do as part of the regular learning process, and not just in formal testing procedures will be important. Assessment using one-to-one task based interviews in a flexible way could be considered by teachers as well as researchers. These do not need to be administered formally but can be incidental during teaching sessions. However, the more formal approach enables the teacher to focus solely on one child at a time, without the distractions of the busy classroom.

Children are rich mathematical thinkers. They are entitled to experience assessments that provide opportunities to show what they know and can do to researchers and educators. In advocating a place for more flexible approaches to interviewing I would argue that it provides greater richness and validity in terms of results for individual children. However, listening is vital.

Downs and Strand (2006) suggested the following guiding principles be used when evaluating assessment methods in both regular early childhood settings and early childhood special education:

- As a general rule, assessment should be restricted to variables that are responsive to intervention on the part of teachers.
- The value of an assessment is the function of its capacity for generating novel or unexpected information; therefore, assessments should be questioned to the extent that they are a source of redundancy, regardless of psychometric considerations.
- Outcomes assessment should be prioritised over fidelity assessments.
- The timing and frequency of assessment should allow for intervention changes in cases in which performance changes are inadequate or less than anticipated.
- In the service of generating and sharing ideas about effective instruction, forums should be established in which teachers present to their peers data reflecting the cumulative education attainments of students under their change. (p. 678)

The one-to one task based mathematics interview would seem to reflect these principles well. Ginsburg (2009) argued that the clinical interview method is an essential component of formative assessment and "indeed, what is the alternate to obtaining detailed understanding of children's knowledge and using it to inform instruction" (p. 126).

References

Abdelhameed, H., & Porter, J. (2006). Counting in Egyptian children with down syndrome. *International Journal of Special Education, 21*(3), 176–187.

Bobis, J., & Gould, P. (1999). The mathematical achievement of children in the Count Me in Too program. In J. M. Truran & K. M. Truran (Eds.), *Making the difference* (Proceedings of the 22nd annual conference of the Mathematics Education Research Group of Australasia, pp. 84–90). Adelaide: MERGA.

Bobis, J., Clarke, B. A., Clarke, D. M., Gould, P., Thomas, G., Wright, R., & Young-Loveridge, J. (2005). Supporting teachers in the development of young children's mathematical thinking: Three large scale cases. *Mathematics Education Research Journal, 16*(3), 27–57.

Brown, R. I., & Semple, L. (1970). Effects of unfamiliarity on the overt verbalisation and perceptual motor behaviour of nursery school children. *British Journal of Educational Psychology, 40*(3), 291–298.

Carpenter, T. P., & Moser, J. M. (1984). The acquisition of addition and subtraction concepts in grades one through three. *Journal for Research in Mathematics Education, 15,* 179–202.

Carpenter, T., & Lehrer, R. (1999). Teaching and learning mathematics with understanding. In E. Fennema, & T. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 19–32). Mahwah: Lawrence Erlbaum Associates.

Clarke, D. J. (1989). *Assessment alternatives in mathematics*. Canberra: Curriculum Development Centre.

Clarke, B. A., & Faragher, R. (2004). Possibilities not limitations: Developing mathematics thinking in children with special needs. In B. Clarke, D. M. Clarke, D. V. Lambdin, F. K. Lester, G. Emanuelson, B. Johansson, A. Wallby, & K. Wallby (Eds.), *International perspectives on learning and teaching mathematics* (pp. 379–395). Goteborg: National Center for Mathematics Education, Goteborg University.

Clarke, B. A., & Robbins, J. (2004). Numeracy enacted: Preschool families' conception of their children's engagement with numeracy. In I. Putt, R. Faragher, & M. McLean (Eds.), *Mathematics education for the third millenium: Towards 2010* (Proceedings of the 27th annual conference of the Mathematics Education Research Group of Australasia, Vol. 1, pp. 175–182). Townsville: MERGA.

Clarke, D., Cheeseman, J., Gervasoni, A., Gronn, D., Horne, M., McDonough, A., Montgomery, P., Roche, A., Sullivan, P., Clarke, B., & Rowley, G. (2002). *Early Numeracy Research Project final report*. Melbourne: Mathematics Teaching and Learning Centre, Australian Catholic University.

Clarke, B. A., Clarke, D. M., & Cheeseman, J. (2006). The mathematical knowledge and understanding young children bring to school. *Mathematics Education Research Journal, 18*(1), 78–102.

Clarke, D., Clarke, B., & Roche, A. (2011). Building teachers' expertise in understanding, assessing and developing children's mathematical thinking: The power of task-based, one-to-one interviews. *ZDM Mathematics Education, 43*(6), 901–913.

Clements, M. A., & Ellerton, N. (1995). Assessing the effectiveness of pencil-and-paper tests for school mathematics. In B. Atweh & S. Flavel (Eds.), *Galtha: MERGA 18* (Proceedings of the 18th Annual Conference of the Mathematics Education Research Group of Australasia pp. 184–188). Darwin: University of the Northern Territory.

Downs, A., & Strands, P. S. (2006) Using assessment to improve the effectiveness of early childhood education. *Journal of Childhood Family Studies, 15,* 671–680.

Faragher, R., & Clarke, B. A. (2014). *Educating learners with Down syndrome: Research, theory and practice with children and adolescents*. London: Routledge.

Faragher, R., Brady, J., Clarke, B. A., Clarke, D. M., & Gervasoni, A. (2008). Narrowing the gap: Empowering teachers and parents through understanding how children with Down syndrome develop mathematically. In L. Graham (Ed.), *Proceedings of the 'Narrowing the Gap: Addressing Educational Disadvantage' conference* (pp. 56–62). Armidale: SiMERR.

Fleer, M., & Quinones, G. (2013). An assessment perezhivanie: building an assessment pedagogy for, with and of early childhood science learning. In D. Corrigan, R. Gunstrone, & A. Jones (Eds.), *Valuing assessment in science education: Pedagogy, curriculum, policy* (pp. 231–247). Dordrecht: Springer.

Fuson, K. (1992). Research on whole number addition and subtraction. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 243–275). New York: Macmillan.

Gervasoni, A. (2004). *Exploring an intervention strategy for six and seven year old children who are vulnerable in learning school mathematics*. Unpublished PhD thesis, Latrobe University, Bundoora, Australia.

Ginsburg, H. (2009). The challenge of formative assessment in mathematics education: Children's minds, teachers' minds. *Human Development, 52,* 109–128.

Ginsburg, H., Klein, A., & Starkey, P. (1998).The development of children's mathematical thinking: Connecting research with practice. In I. E. Siegel & K. A. Renninger (Eds.), *Handbook of child psychology* (5th ed., Vol. 4): *Child psychology in practice* (pp. 23–26). New York: Wiley.

Higgins, J., Parsons, R., & Hyland, M. (2003). The numeracy development project: Policy to practice. In J. Livingstone (Ed.), *New Zealand annual review of education* (pp. 157–174). Wellington: Victoria University of Wellington.

McDonough, A., Clarke, B. A., & Clarke, D. M. (2002). Understanding assessing and developing young children's mathematical thinking: the power of the one-to-one interview for preservice

teachers in providing insights into appropriate pedagogical practices. *International Journal of Education Research, 37,* 211–226.

Mulligan, J., & Mitchelmore, M. (1996). Children's representations of multiplication and division word problems. In J. Mulligan & M. Mitchelmore (Eds.), *Children's number learning: A research monograph of MERGA/AAMT* (pp. 163–184). Adelaide: AAMT.

Schorr, R. Y. (2001). A study of the use of clinical interviewing techniques with prospective teachers. In M. van den Heuvel-Panhuizen (Ed.), *Proceedings of the 25th conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 153–160). Utrecht: PME.

Wishart, J. G. (1996). Avoidant learning styles and cognitive development in young children. In B. Stratford & P. Gunn (Eds.), *New approaches to Down syndrome* (pp. 173–205). London: Cassell.

Wright, R. (1998). An overview of a research-based framework for assessing and teaching early number learning. In C. Kanes, M. Goos, & E. Warren (Eds.), *Teaching mathematics in new times* (Proceedings of the 21st Annual Conference of the Mathematics Education Research Group of Australasia, pp. 701–708). Brisbane: MERGA.

Barbara Clarke is an Associate Professor in Mathematics Education at Monash University, Victoria, Australia. The major focus of her writing and research has been concerned with mathematics teachers, their practice, and their professional development. Her current research focuses on the mathematical development of children with Down syndrome with the support of teachers in inclusive settings