ASSESSMENT OF MATHEMATICAL DEVELOPMENT IN EARLY CHILDHOOD: SOME VIEWS OF PRESCHOOL PRACTITIONERS IN REGIONAL AND RURAL AUSTRALIA

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ABSTRACT

As part of the project *Mathematical Thinking of Preschool Children in Rural and Regional Australia: Research and Practice* directors, teachers, and assistants in prior-to-school settings from regional and rural eastern Australia were interviewed to ascertain their beliefs and practices concerning early childhood mathematics. This paper reports the responses to questions about their assessment of children's mathematical activity and development. The practitioners provided examples of both incidental and planned assessment activities, the different forms these took, methods of recording, and how the results were used.

Keywords: Assessment, evaluation, reporting, observation

ASSESSMENT/EVALUATION IN THE EARLY YEARS

Assessment is often thought of as testing, but it also includes other types of evaluation such as formal and informal observations. In early childhood settings, observation of children's development is more common than testing, with carers seeking evidence of growth across a range of intellectual, language, social, emotional, as well as physical understandings and skills. In this paper, the focus is on the assessment of very young children's mathematical activity and development.

The Australian position statement on early childhood mathematics (AAMT/ECA, 2006, p. 3) focuses on prior-to-school aged children's mathematical development. It proposes that

> *Early childhood educators should adopt pedagogical practices that assess young children's mathematical development through means such as observations, learning stories, discussions, etc. that are sensitive to the general development of the child, their mathematical development, their cultural and linguistic backgrounds, and the nature of mathematics as an investigative, problem solving and sustained endeavour.*
>
> *(AAMT/ECA, 2006, p. 3)*

In a similar vein, Clements, Sarama, and Liu (2008) argue that the critical criterion for assessment tasks in early years is that they are 'central and coherent … with children's thinking and generative of future learning' (p. 459). Specifically, they argue that examples of characteristics for tasks that are appropriate for 0–5 years and mathematical in nature, are those that demand attention to part-whole relationships,

number composition, identifying and constructing shapes, position, measurement, and pattern (Clements et al., 2008). More broadly, Carr (2001) outlines a range of values for practitioners: to understand, get to know, be 'in tune' with individual children; to understand children by using the documentation as a catalyst for discussion with others; to share information with others in this setting; to reflect on practice; and to plan for individuals and groups (p. 19). Taking a more holistic perspective than Clements and his colleagues, Rogoff (1998) pointed out the importance of recording 'transformation of participation' when assessing students. Carr (2001) developed this further with the notion of a conceptual (c.f. developmental) hierarchy that include situated learning strategies and dispositions: not only developing appropriate knowledge and skills but also being ready, willing, and able to participate in and change learning places and activities.

Across Australia, teachers in most formal early childhood settings (as opposed to casual care undertaken by women in home-care settings) must undertake observations of children and to keep written records of these. Often the minimum number of records per child is prescribed by registration authorities. It is usually expected that the records will be available to parents, and they must be available during inspections of childcare centres and pre-schools. The records are meant to be used in program planning, so it is common for centre accreditation and re-accreditation teams to expect to see links from (a) evidence of what children know and seem ready to learn, across to (b) specific activities in programs. In a few cases, the format of records is prescribed. For example, some franchise managers have very strict guidelines, schedules and templates in place, and staff undergo intensive training in their use. However, the majority of centres are free to use a range of methods for documentation and reporting. Further, while, 'language' and 'literacy' are common headings in any prior-to-school observation and reporting process, it is not so common for 'mathematics' or 'numeracy' to be included. Thus what the interviewees do in practical settings was of interest in this research project.

THE RESEARCH PROJECT

The project Mathematical Thinking of Preschool Children in Rural and Regional Australia: Research and Practice (Hunting et al., 2008) has been described earlier (Perry, 2010). This paper presents results and analysis from Questions 8 and 9 of an interview designed for the project (see Perry, 2010). These two questions focused on early childhood professionals' beliefs and practices in relation to assessment:

Q 8. How do you know if a child is making progress in their mathematical development?

Q 9. Do you or the Centre document children's participation in mathematical activities? [If yes, then …] In what ways do you do this?

RESULTS AND DISCUSSION

This paper focuses on reasons that the interviewees gave for assessment your children, the methods they use to do this, the records they make, and how the records are used.

Why assess young children?

The literature outlines many reasons for documented assessment of young children. Assessment and reporting are time consuming but are expected roles for early

childhood practitioners. The reasons for gathering and documenting evidence of children's development include:

- identifying strengths and weaknesses of individual children (e.g., for program planning, reassurance for parents, noting any areas that may need specialist attention, to check 'competencies' considered necessary to proceed to school);
- identifying strengths and weaknesses of the whole group/class (e.g., for curriculum planning);
- identifying strengths and weaknesses of institutions (e.g., for system accountability and planning, to inform professional development); and
- identifying strengths and weaknesses of large cohorts (e.g., for comparing the development of children from different backgrounds, to inform or provide leverage for system change).

While the interviewees were not asked why they assess children, some included this information while discussing their practices and opinions. Many mentioned the need to note developmental progress:

> *If there has been some progress … they were initially just doing a yellow hexagon, green triangle, yellow hexagon and now they have got five different shapes and are able to repeat that pattern, there is evidence of progress*.

Others explicitly mentioned programming to develop specific knowledge or skills:

> *When you sit down you give them not a formal assessment, but you realize where they are at … and where you need to take the program next. Maybe you feel if they are not working in that area, you could introduce something different.*

Teachers of 4-year-old children tended to mention assessing readiness for school.

> *Basically we check at preschool level—if they recognize and name the shapes, their numbers, their numerals, counting, counting one to one correspondence. So those things are done; but we don't sort of test on volume, measurement—all those sorts of things.*

Commonly, the interviewees gave reporting to parents as their rationale:

> *I think documentation—whether it is mathematics or anything else—needs to be written for the children and their parents. I don't believe that the regulations own it, or (centre) accreditation owns it, or any other Government organization. It belongs to the children and the parents, and so they are written that way.*

Two of the professionals thought that the assessment was a form of surveillance of their effectiveness as program planners and teachers.

> *The Centre management needs to know which rooms are performing well—and the parents. You can't call it a 'learning' centre and say what you taught them if you do not keep evidence.*

How are children assessed?

There is ample sensible advice about ways of assessing children's mathematical development in prior-to-school settings. For example, the NAEYC and NCTM jointly wrote:

> *Beginning with careful observation, assessment uses multiple sources of information gathered systematically over time. … Mathematics assessment should follow widely accepted principles for varied and authentic early childhood assessment. For instance, the teacher needs to use multiple assessment approaches to find out what each child understands--and may misunderstand. Child observation, documentation of children's talk, interviews, collections of children's work over time, and the use of open-ended questions and appropriate performance assessments to illuminate children's thinking are positive approaches to assessing mathematical strengths and needs.*
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> *(NAEYC/NCTM, 2002, pp. 12–13)*

The formal assessment of young children's mathematical development commonly uses psychology-based instruments, mathematically focussed instruments, or an observational approach. Each has its strengths and limitations, although Clements and his colleagues (2008) argue that the critical criterion for assessment tasks in early years is that they are 'central and coherent … with children's thinking and generative of future learning' (p. 459).

Psychology-based instruments are most likely to be used by specialists in specific circumstances—particularly when a child's development and behaviour seem poor, or when decisions must be made about readiness for school. Frequently a battery of tests is used to assess children across a range of competencies.

> *The specialists have quite a few tests. None specifically for maths—mainly behaviour and social. Some of the questions might be, like, saying a few numbers and asking the child to repeat them but that is memory, not knowing what they are.*

Common criticisms of such tests include that

- they are often technical and certainly not user friendly for childcare assistants;
- they are usually devoid of contexts that are meaningful for children;
- implementation by strangers is likely to skew results;
- the formality of testing procedures sometime bars child-friendly means (such as asking the question in a different way).

On the other hand, mathematically-focused assessment focus on the development of children's mathematical knowledge and skills. Usually, these have been norm referenced against large numbers of young children in a range of age groups, providing a well-researched point of comparison with respect to typical development. These have been used in unintended ways and some do have troublesome characteristics (see, for example, Clements, Samara and Lieu, 2008; Mousley, 2009), and as always perceptions of validity across a range of circumstances should be questioned (Carr, 2001). In Australia, readily accessible instruments include Doig, 2005; Doig and de Lemos, 2000; Thomson et al., 2005. However, the use of only one test was reported by an interviewee:

> *The PSFO [Pre-school Field Officer] uses I Can do Maths as well as a language test.*

In fact, most of the interviewees did not rely on standardised tests—either psychology-based or mathematically-based—because the most commonly-reported form of assessment was observation.

Observational approaches

A common criticism of observational approaches to assessment in the early years is that it is difficult to obtain normative data. At what age, for example, are children typically able to order numbers, or have a good understanding of 'longer'? But if one is interested in the development of a particular child over time, in children's responses to specific activities, in the interaction of different types of learning (such as mathematical and social), or in the needs of a particular group of children, then observation is an ideal approach to evaluation. Although taking notes based on observation is time consuming, it has the advantage of not taking teachers and children away from they do best: working together on engaging activities.

The interviewees reported examples of observation that takes the form of relatively casual scrutiny, with noting of not only conceptual but also social pointers:

> *[They are progressing] when they seem comfortable enough to do it on their own and try and get their other friends to come into their play that they are doing with maths, and explain that to them.*

Others involved verbal interactions, with an emphasis on conversations involving listening to children:

> *I think you have got a fair idea from the conversations that you have with children when they are interacting with things where they are at and also from observing them. Children make incidental comments about things that you have said, and you might think that was a bit over their head but the following day they are bringing up again wanting to know more. I think that that is a good indication of how they are building on their knowledge.*

One respondent reported that in her centre they deliberately program for progressive observations using task-based observations:

> *… putting out an activity for an Ob and saying 'Look what they can do now', then later putting out a similar activity—but not the same—and seeing if they can grasp that it is the same sort of thing, and what they have learnt, or how they manage it better.*

More formally, such planning may be structured around individual development plans:

> [*We use] individual learning plans. We work with objectives, in the focus group style, working with a couple of objectives over a couple of weeks and then following that up later on in the year and [seeing] how we have gone.*

In relation to the observational focus, some respondents indicated that they just record what they notice, while others looked for and noted specific, mathematical skills:

> *They can talk about and identify concepts like which is heavier, which is longer, which is shorter, which is taller and those sorts of things.*

> *You will notice that there are blocks or something, and counting them goes 'One, two, three, four, five, six, seven, eight, nine, ten'. Then you actually notice that they are getting one to one correspondence … Then they will start to identify numbers …talk about numbers before or after.*

At times, such concept-based observation of progress is made over extended periods of time:

> *You can try and pound it in [then] ask them to redo it straight away and it won't show, but yet six months down the line out it comes and you are thinking, 'Hang on, I tried to teach you this here six months ago and now you are doing it!' … It's good to watch.*

Observations at the centres that participated in this research are recorded in portfolios, checklists, learning stories, and storybooks—or more commonly some combinations of these.

Portfolios. It seems that the most dominant method employed by early childhood practitioners is portfolios. Some were collections of different types of records pertaining to individual children:

> *We take a lot of photos of children, which can show the development of different things that they have done across the area—not just mathematically.*
>
> *We have what we call their 'portfolios' which has got photos of them interacting with the different things, samples of work that they have done, observations that the staff have taken. It may relate to a photo, or might just be an incidental [event] that has happened throughout the day.*

Other portfolios were used to document each day or week's activities.

> *We keep a daily journal, which is a collection of photographs and things just telling the parents what is going on.*
>
> *It's a diary for the week, and there is a column to note obs. They might be about a child, or an activity—what worked well or the problems.*

Checklists. Checklists are also being used to record observations of individual children. These were being used heavily across the age groups in the centres:

> *We do the checklists once a month for each [baby and toddler]—more than that if we find time of notice anything special.*
>
> *We do observations on them and we probably do the same [3 year old child] once a week. So we will sit down and we will be talking to them like … 'I have lost one of my pencils. Can you find it for me? It is a red one?' And then when they get it, 'Tell me how many I have'. They might tell you, or it will stay the same, or they are not interested. … It is the basics like the numbers, colors, shapes, and all that. We check them once a week just to see if they are progressing.*
>
> *One of the tools that we were given through what was 'DEST' to monitor children was particularly for Aboriginal preschoolers. It is a pre-literacy and pre-numeracy tool and is basic: Can they recognize the number? Can they recognize name, whatever, … The way that you report with that is often 'Lots of adult support', 'Some adult support' and then 'Independently'.*

Some centres structure such records around set tasks:

> *We have to write the different dates when you observe the child and it has set activities that you have to do … Like it will have numbers, and we will have five fish, and the kids have to count them before they color them in.*

It seems to be a common belief that such observation checklists can be used to record children's progress through a hierarchy of skills.

> *At least then three times a year we work through different programs with the children to see where they are in their maths and in their recognition of the numbers. So you know how far they have progressed up the scale.*

While such checklists are, at times, used for formal reporting to the relevant state government departments, there was some evidence that they are also used by early childhood teachers to note development and to inform planning:

> *Just monitoring it over a year that they might be doing this now, but they can do the whole lot by themselves at the end of the year … You need tools that are quick and easy.*

We do a checklist once a month. It gets summarized by the team leader and because or re-accreditation, we have to be able to show what information was used for program planning.

However, some people realized the limited and convergent nature of checklists.

> *Yesterday I looked at Jamie and ticked off that he recognizes triangles, but nobody would know from that what he knows about triangles. He fitted them into a jigsaw that has several sorts of triangles and other shapes, but there was nowhere to write that he was saying 'three' when he picked up a triangle and 'four' if he picked up a square or rectangle. That is pretty good for a three [year old child], isn't it? When he picked up the circle he did not say a number, so I asked him 'How many sides?' He said 'round and round and round', and traced his finger around the edge then rolled it on the table like a wheel while repeating 'round and round'. But he gets the same tick as a child who only says 'circle' or 'triangle'. A tick does not tell me what to provide next for Jamie.*
>
> *So, he can say 'square'. Tick! But can he talk about what makes it a square, and does he call a rectangle a square too? There is nowhere to write what he really knows.*

Aside from checklists, many of the same centres used more qualitative, interpretive approaches to evaluation and record keeping. These were also based on observation, but the records were more detailed and varied.

Photographic and work samples. Many of the interviewees take photographs of children's activities.

> *Their block building is become more sophisticated. … When they start off they might be fairly haphazard and collapse fairly often, but as they go along they have realized that the base has got to be wider than the top … So really you are capturing their work samples.*

These observations are likely to be put into record books with descriptive accounts of what the children were doing, but some are more a record of activity than of learning. For example, one entry showed a photograph of four children playing in a sandpit:

> *Monday afternoon. The weather was warm so we used water in the sandpit. We played with jugs and cups. We shared well and took it in turns to use the hose. We got very wet but it was fun. Annie filled up four jugs.*

However, while the intention is to record activity rather than learning, such records can form the basis of further learning if they are used well by the carers and parents, such photographic and narrative records have the potential to bring together the recording of social factors, attitudes and dispositions, and contextual or cultural factors as well as intellectual, and physical development. They can also blur the artificial divisions between individual and group experience and between activity and competency.

> *I like writing them. It's like telling a story. The parents say they like reading them. … They are good for parents and sometimes you see them talking to their kids about the photos.*

> *We document right across the spectrum and we look specifically at some really basic mathematical things like color recognition, shape recognition, some spatial stuff … We do interviews with parents at the end of second term and then we will do them just before they go to school if the parents want them. … I will say, 'These are all of the things that I have seen at preschool does this back up the things that you have done at home?'*

Such documented records run the risk of lacking focus: their complexity and amorphous nature do not keep a carer focused on any specific purpose of the activity or on the capabilities, relationships, and intentions of the children. One respondent described how they add a list of concepts to their activity-based photographic and written records:

> *We also take photos of children doing things that are appropriate to recording. For example, a couple of weeks ago the children used blocks and magnetic blocks … Somebody suggested a bowling alley. So we had the bowling alley across the room. We talked about how the lines had to be straight with the blocks … and how many pins we had to have … So we took a photo and then on the page we said 'Some of the children made a bowling alley …', [with a] bit of a description. Underneath we put some of the concepts that we were dealing with—speed, size, distance, as well as number. … So that will go home to parents.*

Structured accounts. Some centres provided templates for accounts of activities. In one centre, for example, the carers are expected to include points about 'Doing, Thinking, Talking, and Following instructions' in each of their written evaluations.

> *These change sometimes. At a meeting we had about a month ago, we decided to focus more on teaching the children to follow instructions so that was when we added that one. We used to have 'Attitudes' but that was very vague. You can still include what you want, but you have to say something about each of the four things we are focusing on.*

Learning stories. A further step is taken when professional write learning stories (Carr, 2001). While this term is interpreted variously, the common feature is a written 'story' about an activity that had potential for children's learning. These stories differ in length, the amount of detail included, whether they focus on one child or a group, and their structure. In some early childhood courses, students are taught to include specific aspects (such as the potential learning involved, evidence of learning, and implications for subsequent planning). Carr (2001) stresses that there are four processes involved in constructing a useful learning story: describing, discussing, documenting and deciding.

Learning stories are being used by some researchers in Australia. Perry, Dockett, and Harley (2007), for example, linked the learning stories approach to an extensive numeracy matrix of 'powerful' mathematical ideas that could be used to assess children's mathematical learning and to plan appropriate activities. Only one interviewee, however, mentioned this approach to documentation.

> *I use learning stories like I leaned at university. The other team leaders don't.*

Story Books. Here, a record of a memorable activity is made into a book for the room's library shelves.

> *I have made storybooks … So, we made jelly one day—a planned experience —so we were guessing what was going to happen, what do I need to do? A lot of the children knew what we needed to do to make jelly, and so we made up a story about that. It sits in our bookshelf, and the children are able [use/borrow it].*

Reporting assessment outcomes

It was surprising that some of the very detailed portfolios kept in the centres were merely filed, especially when they were about individual children. That is, many were not sent home or otherwise seen by parents, but were kept mainly for more formal purposes, including re-accreditations of the centre.

> *We file them. Sometimes we have to look back, with the child psych expert for example, to help see what the child can do. Mainly they are our way of recording the obs that we have to do, though.*

> *[Individual portfolios] enable us to track progress, which was something that I was finding difficult in documentation of a day book where you are documenting the day's events. It was too hard to see the progress that was happening … So we tend now to focus more on the documentation in their individual files rather than group documentation, although we still do that.*

On the other hand, some portfolios were constructed for an immediate and mixed audience. For example, they can be used to display an emerging curriculum:

> *Documenting an emerging curriculum is something that I am still exploring. … Our portfolios are labeled in terms of aspects of the program so we do have a maths and science section that will have things like our project work, table activities, and outdoor play.*

Others were sent home regularly and were seen as a means of documenting engagement and progress over time as well as a means of regularly reporting to families:

> *We have a 'Child's Summary' that goes home to each family that breaks up into language and literacy, mathematics, and so on.*

How the records are used

Some centres focused on program planning, some on information for parents, some on transition to school, and some on centre re-accreditation.

Program Planning. It is clear that in some centres observations are used for setting learning or developmental goals, either formally or incidentally.

> *We have individual plans for the children, so you are making observations of what is going on, and you only track his development in that area.*
> *Say Abby is making shapes with straws and playdoh. 'What would you call this shape? [Square] A square! And how many sides are there? How many straws?' So you can assess what they know and then if they know you can go on to a challenge like 'So how could you make it a triangle?'*

Information for parents. It was clear that some of the practitioners used their assessment records well to encourage parents to support their work.

> *But also talking to parents and saying 'This is what Owen did. He described us all and had us all set out' and you get so much feedback from talking to the parents about what they might be doing at home.*

However, some felt that the parents did not show an interest in their records, even though the carers recognized advantages for curriculum planning:

> *We put the program up each week, and the menu, and we have the learning stories available next to the sign-in book. Who looks at them? Not many parents—perhaps just a few each week. The Department when they do an evaluation, but they do not read them or appreciate all the time that goes into writing them every day. I eat lunch over the computer every day, spend a fortune on printing photos and spend ages recording details about what the children did but feel very skeptical about the whole exercise. It is such a waste of time. [Interviewer: Then why do you put so much time into producing these wonderful, detailed accounts?] I learn a lot—about the activities and the children. It is when I do my thinking about what to do tomorrow and next week. I wish it was appreciated though.*

Two early childhood professionals spontaneously mentioned a danger with checklists, claiming that parents view checklists as lists of things that children *should* know, and that hence they are likely either to blame staff for not teaching well or to use the list as a basis for some home tutoring. One said:

> *One of our mothers asks for copies every time we do an assessment. They are meant to record a child's natural development and for our planning but she thinks that her son should be able to do everything on the list. … Next thing she has given him a lesson at home and she will tell me he knows [it] … Mum expects to see everything ticked. So if I don't cover it, she will.*

Transition-based records. Some teachers in 4-year old pre-school rooms thought of assessment as being evaluation of children's readiness for transition to school.

> *I need it as evidence. If, say, a child is not likely to be ready for school I need to communicate that to parents. Work samples and photographs help explain what is happening—and my written obs.*

While many researchers have argued that such records are also useful for primary school teachers, one interviewee concurred with research findings that point to a communication break-down that results from school teacher disinterest in these records (e.g., Bronstrom, 2002; Hopps, 2004):

> *When a few of my children went off to school last year, the teachers didn't really want anything to do with it … I mean their portfolios will have what they have done over the year … But the teachers don't want to see.*

Centre re-accreditation. It was very clear that accountability was a key driver of assessment and record keeping.

> *This preschool profile is actually part of our funding. We have to do it, but if you don't have Aboriginal children then you don't get this profile and don't have to do it.*

> *You have to have the records for accreditation. That's it—no choice.*
> *It is for centre accreditation, and the management needs to know what we are doing every day and how the children are developing.*

CONCLUSION

Many early childhood organisations across the world would agree with the statement of the USA's National Association for the Education of Young Children [NAEYC] and National Council of Teachers of Mathematics [NCTM] when they proposed that:

> *Assessment is crucial to effective teaching. Early childhood mathematics assessment is most useful when it aims to help young children by identifying their unique strengths and needs so as to inform teacher planning. (NAEYC/NCTM, 2002, p. 12).*

All of the interviewees reported that their centres are involved in accreditation. Very few reported that this did not include noting mathematical development, although aside from centres that used checklists this was not a regular focus—language, literacy and social development were much more common. There was a range of methods used—nearly all based on observation. The most common method of reporting was individual portfolios that include photographs with written descriptions of activities. While in some centres, observation results were used in program planning, the links in relation to the development of mathematical concepts and skills were not usually clear. Some pre-school rooms for 4-year-old children who were soon to make the transition to school used more formal assessment of children's mathematical concepts and skills.

We argue that assessment should be viewed from a socio-cultural perspective that covers a range of contexts (Carruthers and Worthington, 2006). That is, assessment should be embedded in the social and cultural life of the centre and draw on not only the range of activities undertaken across the day but also the individual ways that children approach these. It is social, interactive engagement that should be the focus of observation and recording. Some of the approaches to assessment and

documentation that were reported by the early childhood professionals in this paper are more likely to grow from this perspective than others.

Australian research into the foundations of early mathematics by Mulligan and her colleagues (2005), suggests the relevance of a broad approach to assessing mathematical development, rather than simply focusing on number knowledge for example. The findings of this research are confirmed by recent state implemented frameworks for early childhood in Australia, which routinely include space and measurement as well as number, as well as the Commonwealth Government supported materials for early childhood (Fleer and Raban, 2007).

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