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Refocusing on Oral Language and Rich Representations to Develop the Early Mathematical Understandings of Indigenous Students

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This article examines the nature of oral language and representations used by teachers as they instruct young Indigenous Australian students at the beginning of formal schooling during play-based activities in mathematics. In particular, the use of Standard Australian English (SAE), the mathematical register used, and the interplay with mathematical representations during classroom instruction are analysed based upon the teachers' self-reported practices. The data are drawn from structured telephone interviews with 40 teachers in 15 schools from rural and remote or multicultural settings in Queensland at the initial stage of a large, longitudinal study. The specific aim of the study was the identification of effective pedagogical practices that may assist young Australian students from diverse ethnic and cultural backgrounds to negotiate western mathematical understanding. The findings indicate that despite experience in these settings and focused professional learning sessions, the majority of these teachers report practices which reflect a strong emphasis on literacy acquisition rather than mathematical understanding. It is the contention of the researchers that the use of oral language with a rich selection of mathematical representations strongly supports mathematical understanding.

■ **Keywords:** Indigenous education, mathematics, numeracy, early years

Shnukal (2003, p. 3) identified one of the 'most intractable difficulties for teaching a modern curriculum' as instruction of this curriculum, generally written in Standard Australian English by and for English speakers, to speakers of Aboriginal or Torres Strait Islander languages or dialects. The research reported in this article is a fragment of the findings being revealed in the early stages of a large-scale, longitudinal project (Representations, Oral Language and Engagement in Mathematics: RoleM). Of concern to the researchers is the question of how best to teach early mathematical understandings in order for Indigenous students to acquire mathematics of a sufficiently high level to provide them with the greatest possible success in further schooling. The use of oral language and the interplay between oral language and the use of various representations of mathematical models in the early years of formal schooling is of particular interest in this project.

A simplistic notion of oral language is 'communicating with other people'. However, communication is not a simple concept; it involves thinking, knowledge, and skills. It also requires practice and training. Teachers who believe that oral language acquisition is a natural process for students, requiring little effort and occurring long before attendance at school, assume that the primary learning tasks for students in school are reading and writing (Zhang & Alex, 1995). When this is the case, oral language development is often neglected rather than forming a crucial component of teaching and learning. Furthermore, in many of these classrooms oral language generally is used more by the teacher than the students. In these

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instances it is used to generate *initiate–respond–evaluate* (IRE) sequences (Wood, 2003) and to direct and transition activities; seldom does it function as a means for students to gain knowledge and to explore ideas. In this article, oral language is defined as communication between the teacher and students that is characterised by open as well as closed questions, affirmations, negotiating and verifying meaning, in conjunction with the use of gestures and facial expressions.

It has long been acknowledged that oral language is crucial to a student's literacy development (Aldridge, 2005), and more recently to emergent mathematical development (Krause, Bochner, Duchesne, and McMaugh, 2010). In the early years of formal schooling, an oral language approach to teaching and learning is appropriate due to the limitations of the reading and writing skills of students at this age. However, this becomes problematic when the language of instruction and assessment is not the home language of the students. Such is the case in Queensland where Standard Australian English (SAE) is used in schools throughout the state despite having students for whom English may be a second language, a second dialect, a foreign language, or a first language (Tripcony, 2002). In relation to the teaching of English and literacy, Luke, Land, Christie, and Kolatsis (2002) in their report expressed the view that the highest priority for Indigenous education was attaining high levels of proficiency with SAE.

While SAE is important to the teaching of mathematics, the use of language is only one of the ways of communicating mathematically. For example, Niesche's (2009) proposal was that students should be encouraged to use their home language in the classroom to negotiate mathematical concepts in order to solve mathematical problems. However, a difficulty with this approach has proven to be the lack of home language that has been developed to articulate mathematical concepts. Warren and Young (2008) noted the lack of research focusing on the verbalisation of mathematical concepts and the use of representations with Australian Indigenous students. This article seeks to contribute to this research and to investigate how teachers' pedagogical approaches influence the development of mathematical understandings.

Background

Developing an understanding of mathematical concepts requires engagement in a variety of models and representations; the depth of understanding is inextricably linked to the richness of these representations. Models are ways of thinking about abstract concepts (e.g., counters to represent numbers) and representations are various forms of the models (e.g., placing the counters on a number line or placing the counters on a grid). Mathematical ideas are presented externally (concrete materials, pictures, diagrams, spoken words, and written symbols) and comprehended internally (mental models and cognitive representations) as connections to existing schemas are made. From this perspective (a) mathematical understanding is exhibited by the number and strength of connections in the students' internal network of representations (Hiebert & Carpenter, 1992), and (b) the development of an understanding of mathematical structure that involves determining what is preserved and what is lost between specific structures, which have some isomorphism (Gentner & Markman, 1994; Halford, 1993). It is in the crossing over between representations that the kernel of the concept is situated, and learning occurs in a sequential way as students move across and between representations.

Dreyfus (1991) proffers a four-step sequence that needs to occur in order for understanding to happen. He suggests beginning by exploring concepts using one representation, move to using two representations in parallel, linking the parallel representations, and finally integrating representations. For example, when learning about the number 4, the number is represented firstly by using counters and the sequence 1, 2, 3, and 4. Then the digit names are linked to counting as a finger is moved from one counter to the next. Finally, the number 4 has many other meanings. It is not just four objects but also can be viewed as one less than 5 (which is explored using a 5-frame), the number just after 3 (which is explored using a number track), and double 2 (which is explored using a 10-frame). While moving across these representations oral language is used to assist in making the connections, but this language also changes during the movement. Duval (1999) argues that mathematics comprehension results from the coordination of at least two representation forms or registers: the multifunctional registers of natural language, figures, and diagrams, and the monofunctional registers of notation systems (symbols) and graphs. As Smith (2006) states, the representation becomes part of the knowledge of the learner; it is an integral component of the objectification process.

The quality and depth of teachers' knowledge of mathematics is a positive predictor for students' achievement across all levels of schooling, however, the gains in mathematics are greatest for students during the first three years of school (Hill, Rowan, & Ball, 2005). While this relationship is still positive in the later years of schooling, the magnitude of the gains is not as great. Thus, teachers' content knowledge plays a crucial role even in teaching of very elementary mathematics content. Moreover, teachers in the early phase of schooling often choose these settings to avoid teaching mathematics as it is perceived as rule-based with a rigid pedagogy involving the use of a textbook and worksheets. In this paradigm the emphasis is towards students memorising and recalling rules and facts (Boaler, 2000). For many early childhood teachers this perceived pedagogy is at odds with the dominant discourse of play-based learning.

We contend that the teacher has a crucial role in the learning of mathematics, that is, to ensure that understanding of mathematical concepts is occurring. Filloy and Sutherland (1996) argue that models often hide what is meant to be taught and present problems when abstraction from the model is left to the students. Thus, teacher intervention is a necessity if the development of detachment from the model to construction of the new abstract notion is to ensue. Expression and language are seen as essential to this journey as they give subtle shades of meaning that arise from the students' thinking (Tall, 2004). Thus from a socioconstructivist theory of learning, the teachers assist in selecting and sequencing the models to be used, encourage students to engage in discussions about the concepts, and ensure that students are extracting from the model and representations the mathematical concept. The primary tool for this activity is oral language.

In a mathematical context, oral language is characterised further by teachers and students sharing the same mathematical register and the building of mathematical meanings from experiences. As described by Roberts (1998) a mathematical register is made up of the semantics and syntax used consistently to describe mathematical ideas. When the language of schooling is Standard Australian English (SAE) the mathematical register consists of words that come from two primary sources: (a) everyday English, and (b) mathematics. The words from everyday English may have the same meaning when used in the mathematics register (e.g., *increase*), may have a different meaning (e.g., *table*), or may have a subtly different nuance (e.g., *between*). There are also words sourced from the discipline of mathematics seem to only have meaning in mathematics, such as 'pronumeral'.

In order to be positioned to engage with school mathematics, taught and assessed using SAE, students require an adequate linguistic repertoire (Meaney, Fairhill, & Trinick, 2008). The challenge for teachers and communities is to develop this repertoire in a culturally sensitive manner. This is even more challenging when a particular culture has not labelled a body of knowledge and skills as 'mathematics' and so may not have developed a mathematical register to describe their mathematics. In this article, the proposition is that effective mathematics teaching and learning in schools multicultural in nature or with high proportions of Indigenous students will take place when SAE is used in an oral language approach (i.e., communicating orally about mathematics) in conjunction with rich mathematical representations to develop a mathematical register. In emphasising the place of oral language in these classrooms, a demanding role is assigned to teachers: to actively engage students in learning processes in which they are given opportunities to use oral language; to scaffold and encourage students to communicate their mathematical understanding; and to support students as they explore their own thinking, and to make schematic connections. Furthermore, the 'bundling' of oral language and rich mathematical representations is characterised by movement among and between the representations, with the oral language being the conduit for the movement. We contend that 'good mathematics teaching' occurs when this bundling is frequent and of a consistent high quality. It is within this construct that the teacher and the students create a social constructivist learning environment with oral language being the primary tool for meaning making (Bikner-Ahsbahs, 2006).

If these strategies are accepted as enablers of learning for students from Aboriginal, Torres Strait Islander or multicultural backgrounds, then it follows that there are particular approaches to oral language and mathematical activity that would support teachers to enact these strategies. The particular aims of this article are to (a) explore the approaches currently used by teachers working with these students, and (b) describe an approach that may result in improved learning outcomes in mathematics.

Methodology

A grounded theory approach was used to analyse the data obtained from the teacher interviews. The initial stage of a grounded theory approach involves *open* coding that refers to the process of generating initial concepts from data. A fundamental feature of grounded theory is the application of the *constant comparative* method, which involves comparing like with like, to look for emerging patterns and themes (Strauss & Corbin, 1997). This process facilitates the identification of concepts, that is, a progression from merely describing what is happening in the data to explaining the relationship between and across incidents. In this study, the constant comparative method involved examining various subsets of the initial data, such as responses from teachers in schools with all Indigenous student populations, to identify and describe the concepts associated with oral language and mathematical representations. This required a different, more sophisticated, coding technique that is commonly referred to as *axial coding* and involves the process of abstraction onto a theoretical level (Glaser & Strauss, 1967). Axial coding is the appreciation of concepts in terms of their dynamic interrelationships, and led to *selective* coding which influenced the construction of the conclusions in this study.

Sample

The project involves the participation of 15 schools from communities across Queensland. Ten of these schools have a 100% Indigenous student enrolment and eight of these schools are located in rural and remote parts of Queensland. In this instance, schools that are at least a three-hour drive from a large urban town (of at least 5000 people) are classified as 'rural and remote'. These distances mean that the classroom support teachers experience on a daily basis is minimal. They also have difficulties in procuring resources to use in the classroom to support hands-on learning experiences. Five schools have both Indigenous and non-Indigenous school enrolments, with a large proportion of these students being Indigenous. Two of these five schools are located in a very large metropolitan area, with a high proportion of students from Asia, the Pacific Islands and Africa. Thus they are classified as 'multicultural' schools in the context of this article.

In all 40 teachers were interviewed. All of these teachers taught students in Preparatory, Year 1 (the first two years of formal schooling in Queensland) or a combination of students in both years (a small number of teachers had students in Years 1 and 2). Demographic data were collected from each teacher at the commencement of the project. This data included the number of years they had been teaching, the year level they were currently teaching, and whether they had had prior experience teaching Indigenous students. If they had been working with Indigenous students up to two years, their experience was classified as *minimal*. Experience between two and five years was classified as some, and greater that five years was classified as *extensive*. Tables 1, 2, and 3 present a summary of the demographic data of the teacher participants in the initial interviews.

All of these teachers had participated in a professional learning day conducted by the researchers, prior to the initial interviews, during which play-based mathematics learning activities developed by the researchers were demonstrated and worked through. These learning activities reflected pedagogy that research has suggested supports Indigenous student learning (Owens & Wegener, 1995), namely: a focus on group work, a focus on observing the activity before participating in it, the use of activities that are hands-on and have inherent meaning, and an emphasis on positive relationships between the learners. The learning activities also were based on the theory that mathematical learning occurs through exploring mathematical concepts in a variety of representations and using supportive discourse. All teachers were given a fully developed written form of each activity, together with all supporting graphics and concrete materials ready for classroom implementation. Included in the written form was the specific mathematical language targeted for each activity accompanied by a range of linking and probing questions that would assist students to understand and discuss the particular mathematical concept being developed through each activity. The initial teacher interviews occurred approximately four weeks after the professional learning day.

TABLE 1

The Number of Teachers in Each Year Level (*n* = 40)

Year level taught	Frequency of teachers
Preparatory	21
Prep/Year 1	2
Year 1	13
Year 1/Year 2	4

TABLE 2

The Number of Years of Teaching Experience (*n* = 40)

Teaching experience	Frequency of teachers
Less than 4 years	19
Between 4 and 10 years	14
Between 10 and 25 years	7

TABLE 3

The Number of Years They Had Taught Indigenous Students (*n* = 40)

Indigenous experience	Frequency of teachers
None	9
Minimal	8
Some	14
Extensive	9

Instrument and Data Collection

The interview was structured consisting of 20 questions, five relating specifically to this article. These five questions were:

1. What is your understanding of the term 'oral language'?
2. What role does oral language play in your current practices in mathematics instruction?
3. Describe your level of confidence using appropriate mathematical language.
4. How do you model the appropriate use of language to your students?
5. What ways does your students' proficiency in using SAE affect how you teach mathematics?

Prior to the interview, the questions were e-mailed to all participants, allowing them time to give some thought to their responses. Due to the spread of participants across the state, all interviews occurred by telephone at a time that was convenient to the participants, and were conducted by two research assistants, especially assigned for this task. Each research assistant had a copy of the interview questions and considered the types of probes that would be appropriate to ask in order to gather a fuller understanding of each response. All interviews were audio-recorded for later transcription.

Data Analysis

Open coding was used to break down the interview data into distinct units of meaning. This started with a full transcription of the audio recording of the initial teacher interviews, after which the text was analysed line by line in for each question in an attempt to identify key words or phrases which connected the teacher's self-reported practices to the experience under investigation.

Verbatim transcripts of the interviews were produced for each teacher and these were analysed independently by the researchers. This process exhibited the characteristics of grounded theory data analysis. In the first instance, the researchers independently read each transcript and identified the themes in each, sorted the data into categories, and coded the categories, constantly comparing the data across interviews. Some agreement was reached with regard to the nature of each category, given supporting evidence from the transcripts. In the cases of disagreement, each researcher returned to the original data gathering excerpts to support particular stances until final agreement occurred. In most instances this entailed at least five iterations through the raw data by each of the researchers.

The analysis resulted in the identification of four clear codes each reflecting different approaches to oral language. These were (a) Speaking, (b) Speaking-Linguistic, (c) Speaking-Understanding, and (d) Communication. The next section presents a definition of each of these categories together with examples responses of teacher responses.

Speaking (S). This refers to teachers who defined 'oral language' solely in terms of spoken language, in particular, speaking to the students in Standard Australian English. It involves a focus upon vocabulary and terminology. Examples of this code from the initial teacher interviews include:

> (5) I just emphasise different language that I know the children might not be familiar with yet … so just use it more frequently in the classroom.
>
> (29) Just using the correct language from day one. Not sort of 'dumbing' it down for them.

Speaking-Linguistic (SL). This was used to describe teachers who specified speaking and listening, student mirroring of language, by repeating what they had heard (including teacher correction), and translating between Standard Australian English and student home language. Examples of this code from the initial teacher interviews include:

> (18) When we're going through the games I always use the word, and if there is a home language word we will use that as well.
>
> (22) At the moment we are trying to get them to say more in SAE, so getting them to translate what they are trying to say in home language and translate it into SAE.
>
> (38) I am doing quite a bit of talking with them and so I guess I am using it [mathematical language] a lot and hope they are listening and then using it themselves.

Speaking-Understanding (SU). Teachers who focused upon students understanding the terminology and verified this understanding by questioning were categorised in this code. Some examples include:

> (1) I really make an effort to question students … they need to understand different ways the question is being asked.
>
> (26) In my instruction in mathematics I focus on becoming more explicit with it and helping to understand the different terminologies used within maths.
>
> (33) If they're [students] not understanding the same language, I guess, what I'm talking about they can't understand the mathematical concepts.

Communication (C). This code refers to teachers who described speaking, listening, and using gestures and facial expressions as central to their pedagogical practices. An example is:

> (36) [Oral language] is speaking, learning how to speak, how to make expression, how to use facial expression, how to use nonverbal communication. It's really important to get them moving, doing something with their bodies to be part of it and to gain understanding.

Mathematical Representations (NR, SR, RR) The richness of the use of mathematical representations and models was also determined from the transcripts of the initial teacher interviews. There were three identified codes with regard to the use of mathematical representations and the interplay with oral language. The codes were (a) No representations, (b) Some representations, and (c) Rich representations, and are exemplified by the following quotes from the teacher interview transcripts:

- No representations

> (1) They need to understand different ways the question is being asked (no reference to representations, materials or models).
>
> (7) We model the correct language because it is very easy when you are listening to themyou can start shortening words … (modelling language not connected with representations).

- Some representations

> (6) I find a lot of visual things and then when I am using the word 'more' they can see it too; (9) I will often get them [students] to point to what we are talking about as well.

- Rich representations (variety of modes: verbal, pictorial, graphic, symbolic, and virtual).

> (14) I always model to them as a whole class with resources to support me, so hands-on.
>
> (32) When we were doing 'between' I took photos of the line of children and I put the photo up on the whiteboard and asked 'Tell me all of the children that are between S. and whoever'.

Each teacher was then assigned to a grid location to match their notions of oral language and their self-reported use of mathematical representations. Initially, all of the teacher participants were located on the plot with a horizontal axis of mathematical representation and a vertical axis of oral language approach. In subsequent analyses,

Language				
	Communication (C)	Nil	35	13
	Speaking Understanding (SU)	1,11, 34	20, 26, 28, 30, 32, 36	14, 31
	Speaking Linguistic (SL)	7, 10, 15, 16, 22, 23, 24, 27, 33, 37	2, 4, 8, 9,12, 17, 18, 19, 38, 39	Nil
	Speaking (S)	5, 29, 40	3,6, 21, 25	Nil
		No representations (NR)	Some representations (SR)	Rich representations (RR)
		Mathematics		

FIGURE 1

Plot mapping oral language use and degree of mathematical representation across all schools (n = 40).

different sub-sets of the teachers were plotted to investigate other themes.

Results

Figure 1 shows the initial resultant plot.

Twenty of the 40 teachers were located in the Speaking-Linguistic and No representations (SL/NR) or Speaking-Linguistic and Some representations (SL/SR) grids, suggesting that the preferred practices of these teachers involved a focus on speaking, listening, repeating, and translating (between SAE and home language). The data in this plot suggest that teachers who use rich mathematical representations do so in conjunction with questioning, gestures, and facial expressions (teachers 13, 14, & 31). Also of note is the nil entry for the Communication and No representations (C/NR) location, suggesting that teachers who are concerned about students understanding and demonstrating this understanding appreciate that mathematical representations need to be used in conjunction with the oral language. Research on both Indigenous students' learning of mathematics as well as favoured pedagogical practices for teaching in the early years of formal schooling, indicates that grids Communication-Rich representations (C/RR) and Speaking-Understanding-Rich representations (SU/RR) are optimum combinations for teachers to pursue.

Language				
	Communication (C)	Nil	Nil	Nil
	Speaking Understanding (SU)	1, 11	20, 26	Nil
	Speaking Linguistic (SL)	7, 10, 16, 22, 27	2, 4, 8, 9, 12, 17, 18, 19, 38, 39	Nil
	Speaking (S)	5	3, 6, 21	Nil
		No representations (NR)	Some representations (SR)	Rich representations (RR)
		Mathematics		

FIGURE 2

Plot mapping oral language use and degree of mathematical representation — teachers at schools with all Indigenous student population (n = 23).

Figure 2 shows the plot of the teacher participants who were situated in schools with a population of all Indigenous students. Ten of these 23 teachers lie in the grid described as Speaking-Linguistic with some mathematical representations (SL/SR). This suggests that teachers in this context favour a focus on speaking, listening, repeating, and translating (between SAE and home language) in conjunction with the use of some mathematical representations. No teachers self-reported the use of Rich mathematical representations, and no teachers were identified in the Communication code.

Figure 3 shows the plot of the teachers in multicultural schools. This refers to schools with students drawn predominantly from Asian and Pacific Island backgrounds, as well as some from Indigenous and African backgrounds. These students may have little or no SAE however they may have some proficiency in their home language. Interestingly, 8 of the 17 teachers in the Figure 3 plot are located in grids that the researchers considered to represent effective to highly effective pedagogical practices for the development of mathematical concepts. This plot also clearly indicates that Communication does not occur with No representations, and the converse, that Rich mathematical representations are not employed with Speaking or Speaking-Linguistic approaches.

When the plots of Figures 2 and 3 are compared the following observations can be made

- 8.6% of teachers in all Indigenous student schools are located in the upper-right grids (i.e., C/SR, C/RR, SU/SR, and SU/RR) while 50% of the teachers in multi-cultural schools are located in the same grids
- 79% of teachers in all Indigenous student schools are located are coded as Speaking-Linguistic (SL) while only 29% of the teachers in multi-cultural schools are coded as SL
- Both plots indicate that C/NR, SL/RR, and S/RR are not viable combinations of practice.

Comparing the Preparatory and Year 1 Teachers

This section investigates whether there is a difference between the Preparatory (Prep) and Year 1 teachers' use of oral language and mathematical representations. It should be noted that for the purpose of this data analysis all teachers in Prep/Year 1, Year 1, and Year 1/Year 2 are considered to be 'Year 1 teachers'. In Queensland the philosophical stance to teaching in the Preparatory Year is play-based. This stance changes to a more traditional approach to teaching as the students move into Year 1.

Language	Prep teachers (n = *21*)			Year 1 teachers (n = *19*)		
C	Nil	35	Nil	Nil	Nil	13
SU	11, 34	28	14	1	20, 26, 30, 32, 36	31
SL	22, 23, 24, 27, 37	2, 4, 9, 17, 18, 39	Nil	7, 10, 15, 16, 33	8, 12, 19, 38	Nil
S	5, 29, 40	25	Nil	Nil	3, 6, 21	Nil
	NR	SR	RR	NR	SR	RR
	Mathematics			Mathematics		

FIGURE 3

Plot mapping oral language use and degree of mathematical representation — teachers at multicultural schools (n = 17).

Hence it was conjectured that all teachers with Year 1 students in their classes would be teaching mathematics using a more traditional approach as compared to the Prep teachers. Figure 4 presents the plots that compare the categorical data for Prep teachers and the Year 1 teachers.

The results indicate some movement by the Year 1 teachers towards the top-right corner of the grid, that is, they had a tendency to use a greater variety of representations in conjunction with speaking for understanding.

Discussion and Conclusion

There are a number of insights arising from the analysis of this initial interview data. Firstly, practitioners in early childhood settings often privilege literacy teaching and approach the teaching of mathematics in a similar vein. However, this trend is apparent throughout all early childhood contexts and not just contexts with a large cohort of Indigenous students. Whatever the reason, the result is a limited exposure to mathematical concepts in these settings and the building of foundational understandings, which in turn limits or even hinders students' mathematical ability in subsequent years of schooling

Secondly, the number of years of teaching experience does not necessarily result in a rich use of mathematical representations or a communication level of oral language usage. Nor does extensive experience in teaching in Indigenous schools necessarily result in improved pedagogical practices in mathematics; the predominant focus remains on speaking and listening with the use of some mathematical representations. This focus reflects a reliance on ESL strategies. This seems to dominate the teaching practices in Indigenous schools, as outlined in a widely used program known as *Walking, Talking Texts* that was published by the Northern Territory Department of Education in 1995. A program for teaching and learning English as a second language, *Walking, Talking Texts* provides a very explicit

Language	Prep teachers (n = *21*)			Year 1 teachers (n = *19*)		
C	Nil	35	Nil	Nil	Nil	13
SU	11, 34	28	14	1	20, 26, 30, 32, 36	31
SL	22, 23, 24, 27, 37	2, 4, 9, 17, 18, 39	Nil	7, 10, 15, 16, 33	8, 12, 19, 38	Nil
S	5, 29, 40	25	Nil	Nil	3, 6, 21	Nil
	NR	SR	RR	NR	SR	RR
	Mathematics			Mathematics		

FIGURE 4

Comparing the Preparatory teachers with the Year 1 teachers.

planning and teaching methodology. Teachers support language and literacy learning through explicit teaching of dialectal differences and facilitate learning through the provision of purposeful and meaningful opportunities for students to use the dialects in a variety of contexts.

While this approach is imperative to assist Australian Indigenous students to become proficient in SAE and literacy, its role and appropriateness for mathematical learning needs investigation. In effect, the use of ESL programs like this seems to influence the teaching of mathematics with the teachers taking a literacy approach rather than a numeracy approach to classroom learning that is, attending to the use of language rather than understanding of mathematical concepts. Coupled with the lack of rich mathematical representations, this approach does not allow for the full development of mathematical understandings as described by Dreyfus (1991). As such these teachers are operating within stage one of Dreyfus' model whereby concepts are investigated using one representation.

Whereas a literacy program approach to ESL may be helpful in engaging with early mathematical understandings of the language of mathematics, it must be remembered that mathematics is much more than just expressing ideas in SAE. Given that these teachers were provided with all of the materials needed to use rich mathematical representations in their classrooms, in conjunction with sample probing questions and relevant terminology at the time of the professional development day, it is apparent that an ESL approach was employed by the majority of teachers in schools with high proportions of Indigenous students.

The danger of focusing on an ESL approach is that the interaction soon becomes a linguistic exercise rather than an exercise in developing an understanding of mathematics. In addition, separating the language from the context can lead to misconceptions. It could be argued that acknowledgement of the cultural and linguistic factors that affect the learning of western mathematics is a minimalist type of action that has been ineffective. Such a focus in the mathematics classroom can inappropriately result in a focus on the use of the English language rather than on the acquisition of mathematical concepts (Howard, 1997).

It appears that an ESL approach is *not* as prevalent in what are termed 'multicultural' schools in the context of this project. We propose two reasons as to why this may be the case: (a) these multi-cultural schools are situated in schools that are able to access support for their ESL students from trained ESL teachers; and, and/or, (b) it is not possible or reasonable that a class teacher is able to translate between SAE and the multitude of languages that may be used in their classroom, and so every effort is made to ensure *understanding* of mathematical concepts occurs rather than merely facility with using mathematics terms. The challenge is to improve the quality of teaching mathematics in the early years of formal schooling by encouraging teachers to attend to a combination of oral language communication and rich mathematical representations, rather than an approach which favours repetition, acquisition, and transmission of vocabulary. As this longitudinal study progresses, investigations will be made to determine if the practices of the teachers involved in the project have moved to the desired state of communication with rich mathematical representations as a result of the ensuing professional development days and follow-up at their school sites.

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References

Aldridge, J. (2005). The importance of oral language. *Childhood Education, 81*(3), 177–180.

Bikner-Ahsbahs, A. (2006). Semiotic sequence analysis: Constructing epistemic types empirically. In J. Novotna, H. Moraova, M. Kratka, N. Stehlikova. (Eds.), *Proceedings of the Thirtieth Conference of the International Group for the Psychology of Mathematics Education 2* (pp. 161–168). Prague, Czech Republic: Psychology of Mathematics Education.

Boaler, J. (2000). Mathematics from another world: Traditional communities and the alienation of learners. *Journal of Mathematical Behavior*, *18*(4), 1–19.

Dreyfus, T. (1991). Advanced mathematical thinking processes. In D. Tall (Ed.), *Advanced mathematical thinking* (pp. 25–41). Dordtrecht, the Netherlands: Kluwer Academic.

Duval, R. (1999). Representations, vision and visualization: Cognitive functions in mathematical thinking. Basic issues for learning. In F. Hitt & M. Santos (Eds.), *Proceedings of the 21st conference of the North American chapter of the international group for the psychology of mathematics education* (pp. 3–26). Atlanta, GA: Georgia State University.

Filloy, E., & Sutherland, R. (1996). Designing curricula for teaching and learning algebra. In A. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International Handbook of Mathematics Education* (pp. 139–160). Dordtrecht, the Netherlands: Kluwer Academic.

Gentner, D., & Markman, A.B. (1994). Structural alignment in comparison: No difference without similarity. *Psychological Science, 5*(3), 152–158.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Chicago, IL: Aldine.

Halford, G.S. (1993). *Students' understanding: The development of mental models.* Hillsdale, NJ: Erlbaum.

Hiebert, J., & Carpenter, T. P. (1992). Learning and teaching with understanding. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 65–97). New York, NY: Macmillan.

Hill, H., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371–406.

Howard, P. (1997, December). *Aboriginal voices in our schools.* Paper presented at the Annual Conference of the Australian Association for Research in Education (AARE), Brisbane, Queensland, Australia.

Krause, K.-L., Bochner, S., Duchesne, S., & McMaugh, A. (2010). *Educational psychology for learning and teaching* (3rd ed.). Southbank, Victoria: Cengage Learning Australia Ltd.

Luke, A., Land, R., Christie, P., & Kolatsis, A. (2002). *Standard Australian English and languages for Queensland Aboriginal and Torres Strait Islander students.* Brisbane, Australia: Queensland Indigenous Education Consultative Body.

Macmillan, A. (2009). *Numeracy in early childhood: Shared contexts for teaching and learning.* Melbourne, Victoria, Australia: Oxford Press University Press.

Meaney, T., Fairhill, U., & Trinick, T. (2008). The role of language in ethnomathematics. *The Journal of Mathematics and Culture, 3*(1), 52–65.

Niesche, R. (2009). The use of home language in the mathematics classroom. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia, 1* (704–707). Palmerston North, New Zealand: MERGA.

Owens, L., & Wegener, C. (1995). *Learning style preferences of Aborigines: Implications for teaching mathematics.* Paper presented at the Eighteenth Mathematics Education Research Group of Australasia Conference, Darwin, Northern Territory, Australia.

Queensland Indigenous Education Consultative Body (QIECB). (2002). *Research report on the Standard Australian English and languages project.* Author.

Roberts, T. (1998). Mathematical registers in Aboriginal languages. *For the learning of mathematics, 18*(1), 10–16.

Shnukal, A. (2003). Introduction: Issues in North Queensland Indigenous education. *The Australian Journal of Indigenous Education*, *31*, 1–5.

Smith, E. (2006). Representational thinking as a framework for introducing functions in the elementary curriculum. What is algebra? What is algebraic reasoning? In J. Kaput, D., Carraher, & M. Blanton (Eds.), *Algebra in the early grades* (pp. 133–160). New York, NY: Lawrence Erlbaum.

Strauss, A.L., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Thousand Oaks, CA: Sage.

Tall, D. (2004). Thinking through the three worlds of mathematics. In M. Hoines & A. Fuglestad (Eds.), *Proceedings of the Twenty Eighth Conference of the International Group for the Psychology of Mathematics Education 4* (pp. 281–288). Norway: Bergen University College.

Tripcony, P. (2002, December). *Challenges and tensions in implementing current directions for Indigenous education.* Paper presented at the Annual Conference of the Australian Association for Research in Education, Brisbane, Queensland, Australia.

Warren, E., & Young, J. (2008). Oral language, representations and mathematical understandings: Indigenous Australian students. *The Australian Journal of Indigenous Education, 37,* 130–137.

Wood, T. (2003). *Complexity in teaching and children's mathematical thinking.* Paper presented at the 27th Annual Conference of the International Group for the Psychology in Mathematics Education (pp. 435–442). Hawaii, HI: Psychology in Mathematics Education.

Zhang, H., & Alex, N.K. (1995). *Oral language development across the curriculum, K-12.* ERIC Digest. Bloomington. ERIC Clearinghouse on Reading, English, and Communication.

About the Authors

Susan McDonald is an early career researcher and a Lecturer in mathematics education at Australian Catholic University. Her role on the Representations, Oral Language and Engagement in Mathematics (RoleM) Project is as an academic with particular interest in the pedagogical practices of the teachers located in schools with high proportions of Indigenous students. She is also actively researching the use of LEGO Robotics in the early years of schooling as a means to engage Indigenous students in STEM subjects.

Elizabeth Warren is a Professor of Mathematics Education and the Director of RoleM. She is renowned for her passion in mathematics education, which is characterised by her belief that access to and achievement in mathematics is an issue of equity. Her continued research into improving the outcomes of Indigenous students in mathematics is crucial to bridging the persistent gap in achievement between Indigenous and non-Indigenous students in Queensland.

Eva deVries is a Senior Lecturer at Australian Catholic University and has a key function in the RoleM Project as the creator of high quality teaching resources and professional development opportunities for teachers. Her contribution to early years mathematics education is well recognised throughout the country.