Young Australian Indigenous students:

Engagement with mathematics in the early years

ELIZABETH WARREN and **EVA DEVRIES** report on activities that have been successfully used with young Indigenous students. The activities focus on mathematical communication, representations and early number ideas.

In 2008, we worked with a range of schools to trial ideas that assisted young Indigenous students to engage with mathematics as they enter the school environment. The schools were located in North Queensland and the Brisbane metropolitan area. In three of the schools, all of the students were Indigenous. The participants were in the Prep and Year 1 classes. The project was designed to:

- take into account pedagogy that supports Indigenous students' learning;
- develop learning activities that foster deep understandings of mathematics; and
- enhance students' engagement with mathematical learning.

This article highlights some key pedagogical strategies that assisted classroom teachers to improve Indigenous students' understanding of mathematics, particularly in the area of number. The paper is organised under three main sections, namely, communicating mathematics, representing mathematics, and early number. Each section begins with a brief summary of the research which underpinned the project, followed by examples of learning activities used in the projects, and finally a discussion of students' responses.

Communicating mathematics: Oral language — listening and explaining

The use of spoken language in school and the types of interactions teachers utilise can either advantage or disadvantage Indigenous students. Furthermore, the importance of spoken language as the foundation for all learning is often not fully recognised and many young Indigenous students are not able to make a strong start in the early years of schooling because the discourse of their family often does not match that of the school (Cairney, 2003). This mismatch of home and school language has been shown to disadvantage Indigenous students' in terms of their achievements in literacy and numeracy in the long term (Dickinson, McCabe & Essex, 2006; MCEETYA, 2004).

It is also well recognised that oral communication is dominant in the lives of Indigenous students and that their experiences with print and other literacies is often limited. Patterns of classroom interactions have been shown to disadvantage some students particularly that of teacher questioning, because Indigenous students do not commonly experience this type of interaction at home or within their community. Understanding and accepting Aboriginal English (AE) as a dialect of spoken English used by most Aboriginal and Torres Strait Islander people is vital, and knowing that there are variations across particular communities is important (Haig, Konisberg & Collard, 2005). Although Standard Australian English (SAE) is the discourse of the school, teachers need to create a bridge for young Indigenous students between AE and SAE as they grapple with new language, new concepts and vocabulary presented for numeracy. The focus we took in these classrooms was, therefore, an oral approach, involving young Indigenous students listening to mathematical conversations and explaining their understanding of mathematics in a supportive learning environment. With these young students, our aim was to develop the use of mathematical language in a focussed play-based context. For example, describing numbers in mathematics entails relating their positions to other numbers. This involves a very specific understanding of words such as "between," "next to," "how far," "one more than," "two less than." Many of the students involved in our project entered school with little understanding of these types of words (Warren & deVries, 2009). Figure 1 illustrates the type of hands-on activities used in the classroom to assist students to begin to experiment with the use of positional language as they described objects in a real world context.

Anyone for Breakfast?

Overall activity

Students place the various breakfast items in front of them according to the positional language used.

Students will be:

- acting out positional language according to the instruction given;
- matching the item's position to language.

Language structure of sentences

- On the table, in front of you, place the plate.
- Beside your plate, put your fork.
- Between your sausages, put an egg.

Figure 1. Typical activity used for building positional language.

As the project progressed, teachers found that the Indigenous students' willingness to engage in conversations about mathematical contexts increased. As their familiarity with the language of mathematics increased, their "stories" about mathematical contexts also became more complex. This increased vocabulary also impacted on the types of stories they shared in literacy blocks. For example, instead of simply saying, "The egg is on the plate," they were now sharing that, "The egg is in the middle of the plate. Beside the egg there is a sausage, which has two chips on top of it."

Representing mathematics: Kinaesthetic and visual strategies

Representations are essential to students' understanding of mathematics. They allow students to communicate mathematical ideas and understanding about concepts to themselves and to others. For example, for students to become deeply knowledgeable about number, they need to see numbers represented in a variety of ways: as a set of objects, as different lengths and areas, as bars on graphs, and as distances on number lines. Our approach was to use these representations as we investigated numbers in a way that was hands on, visual and incorporated kinaesthetic learning (Warren, Young & deVries, 2008). Each representation brought a new perspective to the concept and a new set of mathematical language. Figures 2 and 3 shows two of the activities that supported this approach

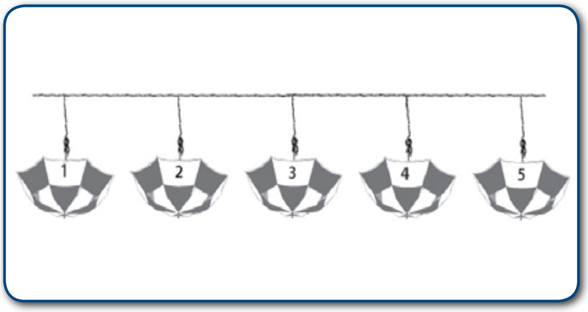

Figure 2. Activity 1: Umbrellas on the number line.

Figure 3. Activity 2: Placing eggs in cartons (ten frames).

For Activity 1, students were given a cardboard umbrella shape with a number on it. They were asked to "hang" their umbrella on the skipping rope and share how they knew where the umbrella went. This activity supported the notion of number as length—the length from the start of the string to where the umbrella is placed. It also assisted the development of young students' understanding of proportion. The discussion continued to explore the idea of numbers being evenly spaced along the skipping rope. For Activity 2, students took turns to roll the dice and place plastic eggs in the carton. The carton comprised 10 spaces in which to place the eggs. With each turn, students were asked to create stories about the numbers of eggs in the carton. Students were encouraged to share stories that included discussing how many eggs were in the carton before they had placed their eggs, how many eggs were in the carton after they had placed their eggs, and how many more eggs they needed to make ten. A typical response to this activity was: "There are six eggs. We need four more to make ten. I put two in. We now have eight eggs. We need two more."

We also acknowledged that two key representations underpin mathematical understanding and communication throughout all levels of mathematics; grids (graphical displays) and number lines. Unfortunately, in mathematics instruction, these have tended to be introduced to students in very formal contexts and taught as an end in themselves. It is important for students to represent their mathematical ideas in ways that make sense to them. It is also important that they learn the conventional forms of representations to facilitate their development of mathematical understanding and their communication with others about mathematical ideas.

We introduced grids (see Figure 4) to young students as mats on the floor that were large enough for them to stand on physically and "be the numbers" themselves. Students were also encouraged to create patterns on the grids that supported the exploration of the conventions of number charts, and create bar graphs. In past research (Warren & Cooper, 2002) we have found that many students experience difficulties with the structure of the hundreds board and examining diagonal patterns (e.g., the patterns formed by the multiples of 3) on these boards. Figures 4 and 5 illustrate two activities that were used with the grid.

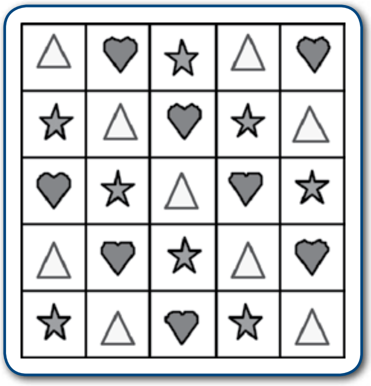

Figure 4. Activity 3: Patterning on the grid.

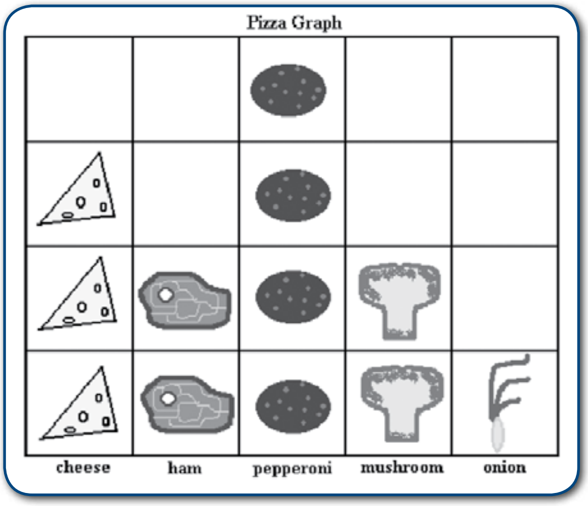

Figure 5. Activity 4: Creating bar graphs on the floor mat.

These activities are designed to allow young students to engage kinaesthetically and visually with patterns on diagonals, the zigzag construction of the number board, and the construction of bar graphs before formalising the board in a number context and a graphing context. Underpinning this engagement was the continual emphasis on oral language, asking questions such as:

- What shape comes next?
- What shapes are between the hearts?
- What patterns can you see?
- How many more pieces of cheese are there than mushrooms?
- How many pieces of cheese and mushrooms are there altogether?

Some typical student responses were:

- "There is more pepperoni than cheese."
- "The smallest one is onion."
- "There is the same amount of ham as there is mushrooms."

Early number: Counting and subitising strategies

A major focus of mathematics in early years' contexts is the development of an understanding of number. The literature identifies two theories of number development (e.g., Gelman & Gallistel, 1978). The first stresses the role of counting. This theory is grounded on the idea of pre-consciousness of counting principles. In this theory, in the preverbal stage, young students' focus on a group of items is upon gauging its magnitude, that is, how many objects there are. Thus the acquisition of the first few number words is achieved by mapping the word onto the magnitudes they have already registered before they can talk. Things are quantified by counting.

The second relies upon the recognition of difference using perceptual or spatiotemporal cues — cues that are not numerical. Fundamental to this theory is the notion of subitising, the ability to quantify something without really counting (either internally or externally). Instead, things are quantified by looking, allowing the number of objects in a small collection to be determined rapidly and accurately. The ability to subitise is not based on preverbal counting (or even fast counting), and is commonly limited to no more than four objects. Research (e.g., Treacy & Frid, 2008; Willis, 2000) has shown that Indigenous students have a natural ability to subitise. The results of our research indicate that this is not necessarily the case. In fact, their ability as they enter school is similar to non-Indigenous students. Our research also showed that the ability to subitise improves with intervention, and it appears that no intervention results in limited ability (Warren & deVries, in press). It is, therefore, important that teachers focus in the early years on creating activities that assist students to learn to count and to subitise.

We used both of these approaches in our classrooms. Figures 6 and 7 show typical subitising activities used in the project classrooms

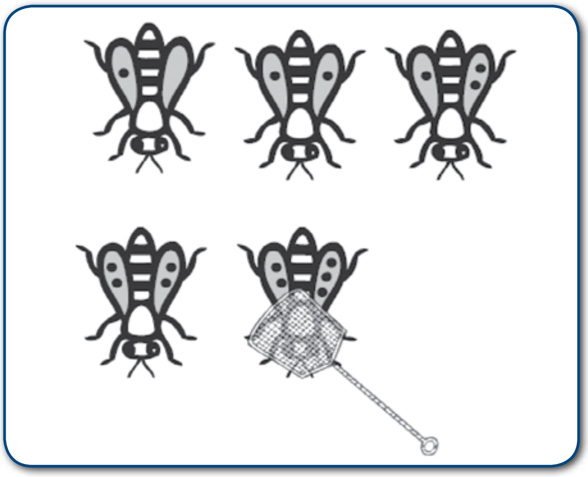

Figure 6. Activity 5: Swatting flies.

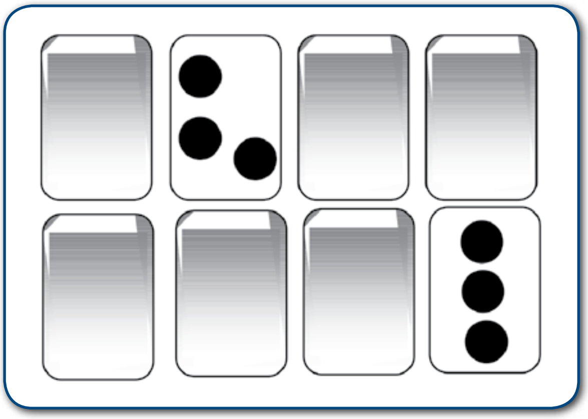

Figure 7. Activity 6: Dot concentration.

In Activity 5, the students sat in a circle with fly swats and the teacher put out flies and quickly called a number. The person who first swatted the fly with that number of dots on its back won the fly. The activity was extended to include questions such as, "Which number is the one just after 3." This activity catered for different ability groups with the teachers making more use of larger numbers on the flies' backs as students' capabilities increased. Students were also encouraged to share how they could recognise 10 dots and explain the patterns that they could see. Activity 6 was a concentration game with students flipping two cards and matching cards with the same numbers of dots.

Students simultaneously engaged with counting activities and subitising activities, but it was the latter that they found most captivating. Engaging with the different visual representations of numbers up to 10 allowed them not only to "guess" what the number was but also to talk about the numbers that they could see on the cards. For example, for a random dot pattern for the number 6, some typical responses were: "I can see four dots and two dots," and "I can see three dots and three dots."

Conclusion

Past research has suggested that success for ethnically diverse students is strongly linked to culturally responsive and empathetic teaching (Gay, 2002). Such teaching consists of two key components, warmth and demand (Fanshawe, 1999). However, warm and demanding "has been interpreted by many teachers as entailing warm relationships and demanding compliant behaviour as opposed to supporting intellectual or academic rigour" (QIECB, 2003, p. 12). Teaching Indigenous students entails more than an awareness of their culture. It requires attention to diversity in terms of both curriculum and instruction. Important to teaching Indigenous students is the recognition that they view learning as a social process. All activities presented in this article reflect pedagogy that supports young Indigenous student learning, namely, emphasising practical experience, hands on activities, group cooperation, and students' engagement. It also recognises that the language of school is different from the language of home. Added to this complexity is the introduction of the language of mathematics.

We are proposing that the language and representations used to express mathematical ideas are complex. All students need the opportunity to play with this language in a supportive environment, allowing them to build their confidence and capacity to use this language to support their learning. Therefore many of the suggestions and examples presented in this article would be beneficial to non-Indigenous students also as they begin their mathematical journeys.

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