Indigenous Children's Ability to Pattern as They Enter Kindergarten/Pre-prep Settings: An Exploratory Study

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The gap between young Indigenous and non-Indigenous children's capability within mathematics is widely acknowledged. This gap is conjectured to exist at all levels of schooling, including pre-school, and widens as children mature. Most of these findings are based on research relating to children's understanding of number and space. Little is known about what knowledge Indigenous students bring to early years settings with regard to patterning, an area that is widely acknowledged as fundamental to the development of concepts, process and knowledge of mathematics. One on one interviews were conducted with 35 Indigenous children (average age 4 years and 4 months) as they entered kindergarten. The results indicate that these children do enter these settings with some intuitive understanding of repeating pattern, and that this knowledge is at odds with the hypothesised learning trajectory (Samara & Clements, 2009) for repeating patterns.

With regard to young Indigenous children, research indicates that little is known about their numeracy capabilities as they enter kindergarten/Pre-prep settings. The results of a large Australian study, Project Good Start, indicated that children from low SES backgrounds perform at a lower level than middle class students on school entry (Thomson, Rowe, Underwood, & Peck, 2005). This study also evidenced the wide gap between the numeracy achievement of non-Indigenous students and Indigenous students as they entered pre-school settings. It is acknowledged in the study that when considering this finding it must be remembered there were only 48 Indigenous children in a sample of 1615 children, and these children were scattered across a range of sites. These findings were also based on the use of 'I Can do Maths Level A' (Doig & de Lemos, 2000), a test developed for 4 to 8 year olds and focussing on the content areas of number, space and measurement. There were no questions relating to ascertaining young children's ability to pattern.

Patterning and the recognition of pattern is fundamental to the development of concepts, process and knowledge of mathematics (Cooper & Warren, 2008; Mulligan & Mitchelmore, 2009; Papic, 2007). The power of mathematics lies in the relations and transformations which give rise to patterns and generalisations. Abstracting patterns is the basis of structural knowledge, the goal of mathematics learning in the research literature (Jonassen, Beissner & Yacci, 1993; Sfard, 1991). It is important to begin the exploration of patterns within the early years setting as it gives children a firmer understanding of number concepts. Papic (2007) also found that students who engaged in patterning activities in pre-school settings performed better in mathematics in the later years.

Patterning activities that children commonly experience in the early years involve repeating patterns and growing patterns. Repeating patterns are patterns that have a discernable unit that repeats over and over again. Children explore simple repeating using shapes, colours, movement, feel and sound. Typically young children are asked to copy and continue these patterns, identify the repeating part, and find missing elements; a focus on single variational thinking where the variation occurs within the pattern itself. The thinking that is engendered in these activities tends to focus on the patterns themselves with little consideration given to their structure or the mathematics that is embedded in the pattern (Liljedahl, 2004). The iteration of an identical unit (either numeric or concrete)

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occurs in other areas of mathematics, multiplicative thinking and measuring. Multiplication requires the repetition of the same numerical unit (repeated addition) and measurement initially entails the iteration of the same nonstandard unit and later the same standard unit. Thus exploring repeating patterns can be seen as the precursor to the development of key understandings that are important to the development of mathematical thinking.

An ontology of children's learning that is currently dominating the early years literature is the learning trajectory. From this perspective, learning consists of a series of "natural" developmental progressions identified in empirically-based models of children's thinking and learning (Clements, 2007). In conjunction with viewing learning as a progression through development hierarchical levels, the learning trajectory sees teaching as the implementation of "a set of instructional tasks designed to engender these mental processes" (Clements & Samara, 2004, p. 83). From this perspective, the act of teaching is secondary to the act of learning. The resultant curriculum consists of diagnostics tests, learning hierarchies and purposely-selected instructional tasks. Fundamental to this perspective is (a) the existence of a large repertoire of empirically-based research evidencing the development of particular concepts, such as number, number sense, and counting, and (b) conducting extensive field tests trialling various instructional.

The theoretical perspective that underpins the learning trajectory is the notion of hierarchic interactionalism (Sarama & Clements, 2009). This theory consists of three main tenets, namely, developmental progressions, domain specific progression, and hierarchic development. In summary these are: 'Most knowledge is acquired along developmental levels of thinking' (Sarama & Clements, 2009, p. 20). These developmental progressions seem to be more auspicious within particular mathematical domains or topics. Within this framework, while levels of thinking are often believed to be coherent characterised by increased sophistication, the learning process is more often gradual and incremental. While the movement between levels can often range from slow to rapid, it is believed that a critical mass at one level must be constructed before movement to the subsequent level effectively occurs. The hypothesised learning trajectory for patterning in the early years is:

Table 1
Hypothesised Learning Trajectory for Repeating Patterns

Age	Developmental progressions	Action with objects
3	**Pattern recogniser**	Has the capacity to recognise patterns, can operate on perceptual input and note regularities.
4	**Pattern fixer** – fills in the missing elements in an ababab pattern	Finds the missing element by continuing to produce the verbal sequence stored in the phonetic 'buffer' (or, visually through, the visuospatial sketch pad).
	Pattern duplicator AB – duplicates an ababab pattern	Can copy the pattern as long as the perceptual support is available for checking the duplication.
	Pattern extender AB – extends an ababab pattern	Can extend the pattern and has less need for constant perceptual support when doing so.
	Pattern duplicator – duplicates patterns without the need for model support	Duplicates longer patterns and patterns with more complex core units.

This hypothesised trajectory was based on previous research findings and pilot studies in four classrooms (Samara & Clements, 2009). While the literature acknowledges the learning trajectory's limitations in terms of the types of patterning experiences it presents, little is known about its applicability to children from culturally diverse backgrounds such as young Indigenous children.

This research project, undertaken by three researchers in a Brisbane Indigenous kindergarten (Warren, deVries, & Thomas, 2009), looked at the mathematical experiences of kindergarten/Pre-prep children (average age 4 years and 4 months). The sample comprised two teachers and their 35 Indigenous children. The overarching objective was to develop culturally appropriate best practice/research grounded teacher and parent materials to support the transition of Indigenous children from home to school with regard to their numeracy learning. Thus the focus of this paper is to explore the intuitive understanding of repeating patterns that young Indigenous children bring to the kindergarten/Pre-prep setting.

Method

Participants

The children participating in this study came from two purposely selected Indigenous kindergarten settings in Metropolitan Brisbane. Both settings catered for young Indigenous children, and were recognised as settings where the teachers were willing to engage in professional dialogue with regard to student learning. The children came from a range of different ethnicities with the most predominant being Indigenous Australian (76.1%). The remaining children were predominantly Vietnamese. This paper reports on the Indigenous children at the kindergartens (n=35). Thus sample comprised 35 children, 18 male and 17 female, with an average age of 4 years and 4 months. One centre had two Pre-prep classes while the other had one. Prior to the administration of the test, the participants had not been exposed to exploring any types of patterns in these kindergarten settings. In Queensland, in the year prior to Pre-prep, students are either at home or in day care, or experiencing a mixture of both. While we cannot categorically proclaim that they had never experienced any type of patterning activities before the administration of the pre test, we can conjecture that it is highly unlikely.

Data Gathering Techniques and Procedures

All children participated in a one on one interview conducted by the researchers. The interview was designed by the researchers and focused on the concept of repeating patterns. The aim of the interview was to identify the preconceived knowledge about repeating patterns that children brought to the kindergarten/Pre-prep setting. The interview consisted of three tasks. Each pattern focused on ascertaining young children' ability to copy, continue, complete and create repeating patterns. The first Task asked the student to copy, continue and complete an abababababa pattern, and Task 2 they were asked to copy, continue and complete an aabbaabbaabb pattern. In Task 3 they were given coloured paddle pop sticks and asked to create their own repeating pattern. Each part of each task was accompanied by a card with a picture of the pattern on it. Children were also supplied with the appropriate concrete materials needed for them to successfully complete the tasks. For example, for part 1 of Task 1 the children were instructed to copy the pattern using concrete lighthouses and ladybugs, and to place their pattern in the rectangle drawn below the picture of the pattern. Table 2 presents the cards used for each task together with the questions asked.

Table 2

Cards Used for Each Task Together with the Interview Questions

Task	Cards	Interview questions
Task 1 – part 1		Copy the pattern. Using your shapes, make the same pattern in the box.
Task 1 –part 2		Continue the pattern along the line. (Gesture along the line)
Task 1 – part 3		Complete the pattern. What is missing?
Task 2 – part 1		Copy the pattern. Using your shapes, make the same pattern in the box.
Task 2 – part 2		Continue the pattern along the line. (Gesture along the line)
Task 2 – part 3		Complete the pattern. What is missing?
Task 3		Using the paddle pop sticks create your own repeating pattern.

The interview was approximately 15 minutes in length. The terms copy, continue, complete, create were not explained to the children as it was necessary to identify if they understood the language used for describing patterns as well as ascertaining their ability to complete the tasks. Data was recorded on an answer sheet by the interviewer. Children's responses were marked as either correct or incorrect. Task 1 Part 2 and Task 2 Part 2 were allocated a possible score of 2, 1 for continuing the pattern in either direction or 2 for continuing the pattern in both directions. All other tasks were allocated a score of 1. Children used a variety of different strategies as they completed the tasks. The following sections describe these strategies.

Copying the pattern. Children used three different strategies when copying the pattern. One group placed each shape on top of the pictures on the card and then pulled down each shape one by one so that they were in the box (Cover and move). Another group first copied all the shapes that were the same and then copied the remaining shapes (Copy part part). The third group copied the shapes in order from left to right (Copy left to right). Figure 1 illustrates each strategy.

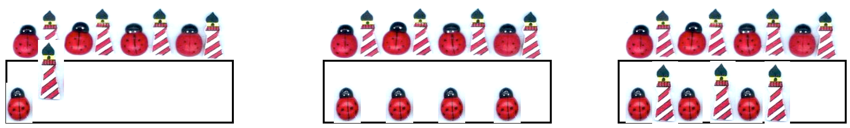

Figure 1. Copying strategies.

Continuing the pattern. When continuing the pattern, there were three different strategies that the student used to complete this task. The children either continued the pattern to the right only, continued the pattern to the left only or continued the pattern both ways. When continuing to the left, some children placed down a shape to the far left and then built up the pattern to the existing pattern.

All of these strategies were recorded and coded. The data was entered into SPSS for analyses.

Results

All 35 children completed the patterning interview. The maximum score for the patterning interview was nine. The mean score was 2.66 with a standard deviation of 1.8. The highest score from the children was 8 with the lowest being 0. Table 3 presents the percentage of children who successfully answered each task, together with the number of children in brackets. It should be noted that for the continuing patterns parts of the tests children were considered correct if the continued the patter in either direction or both directions.

Table 3

Frequency and Percentage of Children who Successfully Completed Each Task

Task		Percentage Correct
Task 1	Part 1: Copy ababab	26 (74.3%)
	Part 2: Continue ababab	8 (14.3%)
	Part 3: Complete	15 (42.9%)
Task 2:	Part 1: Copy aabbaabb	26 (74.3%)
	Part 2: Continue aabbaabb	4 (11.4%)
	Part 3: Complete	4 (11.4%)
Task 3	Create	6 (17.1%)

For Task 3, creating a repeating pattern using coloured paddle pop sticks, all 6 children created abababab patterns using two different strategies. The first relied on colour to differentiate the elements of the pattern, for example, blue red blue red blue red. The second utilised orientation of the sticks to differentiate the elements, for example, using the same coloured paddle pop sticks but placing one element on the vertical and placing the other element on the oblique.

Students were then categorised according to the strategy they used to copy the pattern. Table 4 summarises the frequency and percentage of students who were allocated to each category and their success at copying the pattern

Table 4

Frequency and Percentage of Students who used Different Copy Strategies and who Successfully Copied the Pattern (n=35)

Pattern	Strategy	Used the strategy	Successfully copied pattern
ababababab	Cover and move	3 (8.6%)	2 (5.7%)
	Copy part part	11 (31.4%)	4 (11.4%)
	Copy left to right	21 (60.0%)	20 (60.0%)
aabbaabbaabb	Copy and move	5 (14.3%)	5 (13.0%)
	Copy part part	17 (48.6%)	8 (14.2%)
	Copy left to right	13 (37.1%)	13 (37.1%)

As indicated in the above table children who used the copy part part strategy were less successful at copying the pattern than children who used the other two strategies. The next section discusses how students who used different strategy when copying the pattern performed on the different parts of each task. After copying the pattern, children were asked to continue the same pattern, and then complete the pattern (see Table 2). Table 5 presents the results of this section of the data analysis.

Table 5
Frequency of Successful Responses for the Continue and Complete Parts of the Tasks

	ababab Pattern			aabbaabbaabb Pattern	
Strategy	Continue	Complete	Strategy	Continue	Complete
Copy & move (3)	1	0	Copy & move (5)	0	0
Copy part part (11)	1	2	Copy part part (17)	1	1
Copy left to right (21)	5	13	Copy left to right (13)	2	3

The results indicate that children who used the strategy of copying from left to right were more successful at both continuing the pattern and completing the pattern. In addition, the 6 children who successfully created a pattern (see Table 2), 4 of these used the strategy copy left to right when copying the patterns.

In summary, children found it easier to copy patterns than they did to continue and complete patterns. They also found it easier to complete an ababab pattern than they did to continue the pattern. Duplicating a more complex pattern (aabbaabbaabb) proved less difficult than continuing and completing a less complex pattern. Finally, children who use the strategy of copying a pattern from left to right were more successful than other children on all parts of the test, including their ability to create their own repeating pattern.

Discussion and Conclusions

This paper begins to document the thinking about repeating patterns that these young Indigenous children brought to the kindergarten/Pre-prep setting. It also provides further insights into the conjectured learning trajectory (Clements, 2007). Three main conclusions are drawn from the data.

First, as can be seen from the results (see Table 1) most of the children had already begun their 'patterning journey' as they entered kindergarten. The results also indicated that the exact order presented for the learning trajectory is somewhat at odds with what these Indigenous students could do. For example, many Indigenous children found duplicating a pattern easier than 'fixing' the pattern. They also found duplicating a more complex pattern easier than 'fixing' and 'extending' easier patterns. Does this mean that the learning trajectory for patterning is different for Indigenous children or should we as researchers be more flexible in the 'hierarchical steps' that we propose children pass through as they begin to learn new concepts?

The literature presents a second perspective with regard to the ontology of student learning: the learning-teaching trajectory (e.g., Van den Heuvel-Panhuizen, 2008). While both perspectives have many commonalities, the main differences lie in their emphasis on the act of teaching in the learning process, and the prescriptiveness of the resultant curriculum. In contrast to the learning trajectory, the learning-teaching trajectory has three interwoven meanings, each of equal importance. These are: a learning trajectory that gives an overview of the learning process of students; a teaching trajectory that describes how teaching can most effectively link up with and stimulate the learning process; and finally, a subject matter outline, indicating which core elements of the mathematical curriculum should be taught (Van den Heuvel-Panhuizen, 2008). It provides a “mental education map” which can help teachers make didactical decisions as they interact with students’ learning and instructional tasks. It allows for a degree of flexibility in the learning sequence, and acknowledges that quality teaching a key dimension of effective learning. This ontology may provide a theoretical perspective that better aligns with our project.

Second, the findings indicate that how a child copies a pattern provides insights into their ability to see the structure of the pattern as a whole, rather than seeing the pattern consisting of two parts, the lighthouses and the ladybirds. The most successful copying strategy, copying the elements in succession from left to right was also accompanied by a verbal or nonverbal ‘chant’, ladybird lighthouse ladybird lighthouse ladybird lighthouse, reading the grain of the pattern (Warren, 2005). We are suggesting that these actions in unison assisted children to continue the pattern. They were beginning to ‘see’ the structure of the pattern. But seeing structure entails more than this, as many of these children had difficulties continuing the pattern to the left. Continuing to the left required them to start with a lighthouse instead of a ladybird. A common mistake that many children made was to double up on the ladybirds as they continued the pattern to the left, a strategy we termed as mirroring the pattern. We hypothesise that ‘seeing structure’ of repeating patterns requires the identification of two components, identifying the rhythm of the pattern, and breaking this rhythm into the repeating component (Warren, 2005).

Third, young Indigenous students do enter kindergarten/Pre-prep with some understanding of patterning. In fact our past research with prep aged children indicates that there is no significant difference between Indigenous children’s ability to pattern as compared with non-Indigenous children (Warren & deVries, 2009). The results of this pilot study with three groups of children, namely, Indigenous students (n = 14, average age = 4 years 11 months), Other Culture students (n = 11, average age = 4 years 11 months) and Caucasian students (n = 23, average age = 5 years) also indicated that the main significant difference between these three groups of students as they began school was their understanding of number, and not patterning nor mathematical language, and with appropriate teaching actions it was possible to close this gap. It must be remembered that statements such as ‘low-SES children show less proficient mathematical performance than do their middle-SES peers, particularly when meta-cognition is required, but do not lack basic concepts and skills’ (Ginsburg, Lee & Boyd, 2008, p5.) are based on the tests results after these students have participated in school for some years. Ginsburg, Lee and Boyd (2008) point out that these low SES children are also exposed to a pervasive risk factor as they proceed through school, namely, low school quality. Many teachers in these schools fail to provide opportunities for mathematical learning (Ginsburg, Lee & Boyd, 2008).

This paper begins to share some of our results from our project in two Indigenous kindergarten settings. Due to the space limitations we decided not to share (a) the types of activities that were introduced into the settings (b) the teacher actions that began to build young Indigenous children’s capability to pattern, nor (c) the progress that they children made in their understanding. Briefly, the children’s ability to pattern significantly improved over the year and the early childhood teachers understanding of the how they construct themselves as educators engaged in both a play-based pedagogy and mathematics as a curriculum discipline also changed (Thomas, Warren, & deVries, 2010).

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