

CHILD-INITIATED MATHEMATICAL PATTERNING IN THE PRE-COMPULSORY YEARS

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This paper addresses the nature of child-initiated episodes of mathematical patterning prior to formal schooling. In a multi-site case study, children's engagement in mathematical patterning experiences was investigated as was the teachers' involvement and influence in these experiences. A conceptual framework was used to guide the examination of how children generate, engage in, and direct mathematical patterning activity. The analysis of two child-initiated patterning episodes revealed that they provide rich learning opportunities for both the children who initiate the episodes and their peers who share the episodes. The results also highlight the important role of the teacher in fostering children's patterning development.

BACKGROUND

Educators and mathematicians have emphasized the importance of pattern in mathematics and acknowledge its essential role in the development of mathematical knowledge, concepts and processes. In fact, Steen (1990) argued that "Mathematics is the science and language of pattern" (p. 5). Pattern exploration has been identified as a central construct of mathematical inquiry and as a fundamental element of children's mathematical growth (Burns, 2000; Clemson & Clemson, 1994; Heddens & Speer, 2001; NCTM, 2000). The years prior to formal schooling (pre-compulsory education and care services) are widely recognised as a period of profound developmental change, where many mathematical concepts begin (Clements, 2000; Ginsburg, 1997). The salient role of patterning in the development of mathematical knowledge is evident in its inclusion in various curriculum documents (National Council of Teachers of Mathematics [NCTM], 2000; Queensland School Curriculum Council, 1998; Queensland Studies Authority, 2004; Ministry of Education [N.Z.], 1996).

SIGNIFICANCE OF MATHEMATICAL PATTERNING

Young children's knowledge and skills in mathematics are developed and made meaningful through processes such as comparing, counting, symbolizing, classifying, measuring, representing, estimating and patterning. Within the mathematical domain, patterning can be defined as something that remains constant within a group of numbers, shapes or attributes of mathematical symbols or concepts. The arrangement of the group possesses some kind of clear regularity through the use of repetition. For example, Charlesworth (2000) proposed that patterning is a process of "discovering auditory, visual, and motor regularities" (p. 190). Whilst there are three categories of

patterning (repeating, growing, and relationship), repeating patterns are the earliest form of pattern explored (Burns, 2000). Children as young as three and a half years of age display a strong interest in patterns (Ginsburg, Inoue, & Seo, 1999). Ginsburg et al. investigated preschool children's participation in everyday mathematical activities within the educational setting. The aim of their study was to investigate the relative frequency of different types of mathematical activity. Children engaged in pattern and shape activities for 30% of the observed time. This degree of engagement was markedly higher for patterning than for the other mathematically-orientated activities identified, such as dynamics (i.e., the process of change or transformation), relations, classification and enumeration.

Mathematical patterning provides a substructure upon which formal mathematical competencies can be built. Because the study of patterns underpins all mathematical thinking, it has a close connection to mathematical content areas, such as number, geometry, measurement, and data. Although patterning is integral to the mathematics curriculum in the compulsory years of schooling, it is also a feature of other curricula. Patterning opportunities occur across the curricula in science, art, language, music, and physical education. Hence, from a child's earliest years, patterning is foundational within and beyond the mathematics curriculum because it assists children in making sense of their everyday world.

MATHEMATICS LEARNING IN PRE-COMPULSORY SETTINGS

In early childhood education (as with later education), mathematics is not simply “a static network of terms, rules and procedures that are conveyed by teachers and absorbed by students for recall upon demand” (Campbell, 1999, p. 108). Rather, recent curriculum documents describe mathematics as a way of thinking about relationships, quantity, and pattern via the processes of modelling, inference, analysis, symbolism, and abstraction (e.g., NCTM, 2000).

Recent research has provided considerable insight into how children learn mathematics and has influenced current curriculum documents (Ginsburg, 2002). Curriculum documents such as *Early Years Curriculum Guidelines* (Queensland Studies Authority, 2004), *Te Whariki* (Ministry of Education [N.Z.], 1996) and *Principles and Standards for School Mathematics* (NCTM, 2000) currently reflect the constructivist and social constructivist theories of learning. The basic tenet of constructivism, as described by Heddens and Speer (2001) is that “learners construct their own meaning through continuous and active interaction with their environment” (p. 13). Social constructivism, informed by Vygotsky, recognises that learning is a process that occurs within social interactions emphasised by social collaboration and negotiated meanings (Klein, 2000). Social constructivism theory recognises that children's social and material interactions with their environment are the means through which they learn.

Early childhood curricula also recognise the value of play and the use of concrete materials in children's mathematical development (NCTM, 2000; Perry & Dockett,

2002). Young children's play can be elaborate depending on the theme, content, social interaction and the nature of the understandings demonstrated and generated (Perry & Dockett, 2002). Many mathematical experiences occur during children's play. For example, Ginsburg et al. (2000) noted that 42% of observed play activities engaged in by 4 and 5-year-old children featured mathematical experiences. Play is a valuable component of child-initiated curriculum, an approach which recognises children as the source of the curriculum (Perry & Dockett, 2002). Thus, for young children, playtimes provide an opportunity for the exploration of mathematical patterning and other mathematical concepts. Provided that their mathematical experiences are appropriately connected to their world, young children are capable of exploring ideas "in more sophisticated and rich ways than previously believed possible" (NCTM, 2000, p. 103).

RESEARCH DESIGN

Settings and Participants

Two classrooms were chosen for involvement in this study: one preschool classroom (site A) and one preparatory year classroom (site B). The two sites were located in inner city Brisbane and were geographically close (two kilometres apart); they shared similar socio-economic clientele. Both classroom settings were arranged into interest areas such as block corner, home corner, collage table, and sand and water areas. The teachers' daily programs incorporated both teacher-directed times and free play opportunities. Each setting had 13 female and 12 male children and was staffed by a 4-year trained early childhood teacher. Each teacher had in excess of 10 years teaching experience in both informal and formal educational settings.

Data analysis

A case study (Yin, 2003) was undertaken to gain an understanding of the nature and occurrence of mathematical patterning in pre-compulsory settings. Analysis of a total of approximately 80 hours of video observations collected in the two classrooms revealed ten mathematical patterning episodes. Two episodes were initiated by children and the other eight were guided by the teachers. This paper focuses on the observed child-initiated episodes. An episode is defined as an observed occurrence containing some aspect of mathematical patterning behaviour.

CHILD-INITIATED EPISODES

Episodes instigated by the children were explicit (clearly articulated) or implicit (suggested but not clearly expressed). The analysis of these episodes was informed by Stein, Grover and Henningsen's (1996) conceptual framework, which focuses on classroom-based factors that influence student engagement with cognitively demanding mathematics tasks in real classroom settings. The Stein et al. framework was adapted to suit early-childhood settings (see Figure 1) in order to examine episodes that children initiated and that featured mathematical patterning. The framework comprises three phases (as represented by the rectangular boxes). The

first phase depicts the *original context* prior to the child-initiated event. A *child-initiated episode* (phase two) is where a child initiates an occurrence that incorporates an aspect of mathematical patterning behaviour. The third phase, *responses to child-initiated task*, considers the responses made to the child's overtures by both the teacher and class members. The child's peers may contribute to the newly initiated task or engage in dialogue with them and extend the task further. This framework also includes factors which influence the initiation and response phases (phases two and three). *Factors influencing the event* include children's knowledge of mathematical patterning, their interests, and prior experiences. The physical environment and availability of resources can also influence the episode. The *factors influencing participation* in the episode include task appeal, the involvement and encouragement of the teacher and peers, and other participants' knowledge of patterning.

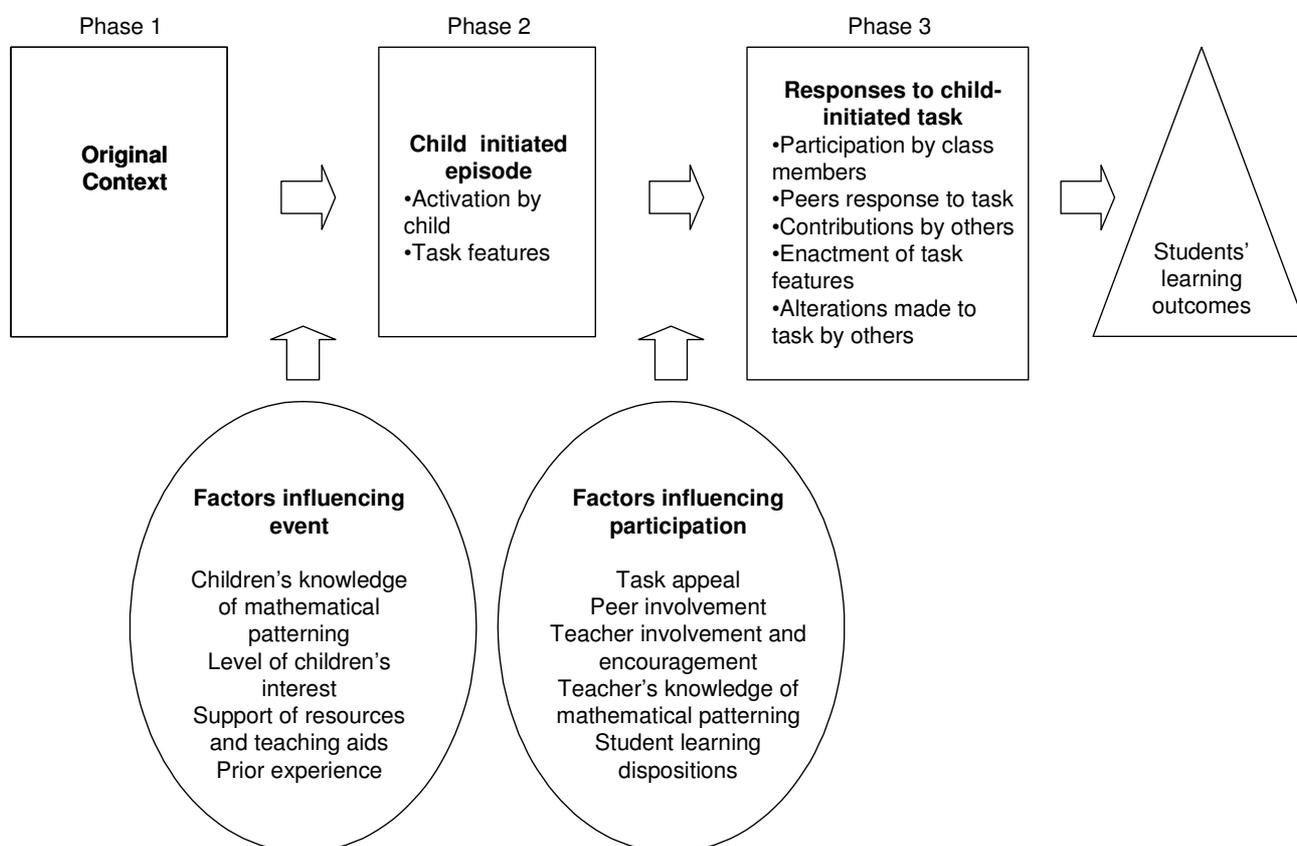


Figure 1: Framework illustrating components contributing to child-initiated activities.

FINDINGS

Two episodes of child-initiated mathematical patterning were observed in the case study. The first episode occurred in the preparatory setting (site B). A child named Ashleigh engaged in an independent activity at the painting easel (*original context*). Paints, paint brushes, paper and toothbrushes were placed in the outdoor area and made available for children to use at their own instigation. Ashleigh was observed using the brushes to paint stripes. She was talking to herself saying “pink, purple,

pink, purple.” She repeated the set twice before beginning a new set of stripes (*child-initiated episode*-phase 2). Another child, Nicole, observed Ashleigh’s painting and said “I’m going to be green, pink, purple.” Nicole made four sets of a green, pink and purple pattern. She then painted lots of green stripes and then put orange stripes in between the green lines. Nicole made more AB patterns using orange/green and purple/yellow. Nicole then said aloud (to who-ever was present) “Look at my patterns” (see Figure 2). Nicole’s participation in this event constitutes the *response to child-initiated task* (phase 3). From a distance, Mrs Jones (teacher) observed the children discussing their creations. Mrs Jones called out “Looks like you are doing some lovely art work”, and continued inside the Centre. Mrs. Jones did not seem to be aware of the opportunity she had failed to capitalise on through not noticing the children’s interest in mathematical patterning. Factors influencing this episode included Ashleigh and Nicole’s knowledge of repeating linear patterns. The available paint and resources provided them with the opportunity to play and explore. Influencing factors such as the degree of teacher involvement and encouragement may have limited the potential of this activity however the children shared their knowledge and encouraged each other to participate in the experience.

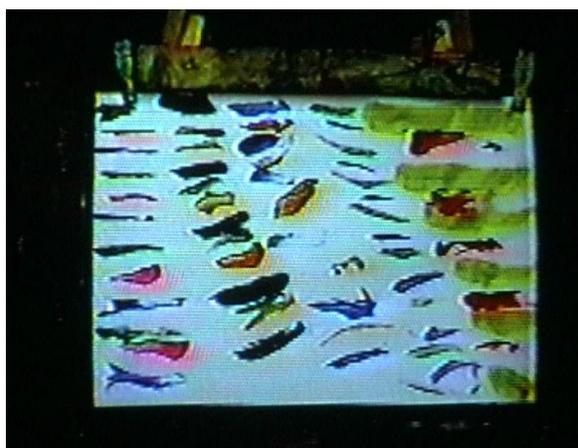


Figure 2: Example of pattern creation using paint colours



Figure 3: Example of pattern creation using tap-tap equipment.

The second episode occurred in the preschool setting (site A). A child named Chelsea was sitting at an inside table independently interacting with manipulative equipment called ‘*tap tap*’ (a hammer and nails construction kit). This construction material had been placed on a table for the children’s use. No instructions for its use were provided by the teacher (*original context*). Chelsea initiated an episode (phase 2) by tapping shapes on to the cork board and described it to other children at the table. “It is a necklace with diamonds – diamond, funny shape, diamond, funny shape, diamond, funny shape” (Figure 3). The teacher questioned Chelsea about her creation. After teacher intervention, another child, Harriet, began to use the ‘*tap tap*’

equipment to make a repeating pattern (yellow circle–green triangle). A second child, Emma, joined the table and created a necklace utilising an ABBA pattern (*response to child-initiated task-phase 3*). Chelsea’s explicit interest in mathematical patterning (*factors influencing event*) seemed to provide the stimulus for other children to join her in creating patterns. The teacher’s involvement and intervention also encouraged the children to participate and create patterns. Three children participated in this episode enthusiastically and the episode provided exposure to mathematical patterning concepts in a play-based experience.

The two child-initiated episodes occurred as a result of children’s current interests and as the individuals shared their thoughts or creations with peers, their interest grew and developed. As other children became involved and contributed to both activities the learning and knowledge was shared, altered, and extended. Table 1 illustrates that all the components of the learning framework were present with the exception of *factors influencing participation* in the first episode. While this episode involved a successful interaction and exchange of knowledge between two girls, the teacher’s acknowledgement and involvement could have also contributed to the episode. As seen in the second episode, when the teacher played a role in the episode more children seemed to engage in mathematical patterning behaviours. During these episodes repeating linear patterns were created by children in unstructured play times. These occurrences were productive exchanges initiated by the children THAT encouraged the exploration of mathematical patterning.

Episode number	Phase 1	Phase 2	Phase 3	Learning outcome	Factors inf. setup	Factors inf. participation
1	✓	✓	✓	✓	✓	✗
2	✓	✓	✓	✓	✓	✓

Table 1: Framework elements observed during child-initiated episodes

CONCLUDING POINTS

Mathematical patterning provides an essential foundation for many mathematical concepts and processes. Williams and Shuard (1982) claimed that “the search for order and pattern ... is one of the driving forces of all mathematical work with young children” (p. 330). As Piaget (1973) attested, children are natural learners and are motivated to learn – their minds are created to learn. Early childhood curricula support these beliefs in their endorsement of constructivism, social constructivism, and play-based learning (NCTM, 2000; QSA, 2004).

Findings in this case study suggest that child-initiated episodes containing mathematical patterning are productive learning occurrences. During unstructured play times, children initiated activities that explored repeating patterns, pattern language, and the elements of linear patterns. These episodes were rich opportunities

where children shared, refined, and developed their knowledge of patterns. The children featured in these episodes manipulated the resources provided in the pre-compulsory settings to explore mathematical patterning. Thus, child-initiated experiences can be powerful learning opportunities with the potential to develop children's knowledge of mathematical patterning in meaningful contexts.

Teachers within the early childhood settings have an essential role in fostering children's mathematical patterning activities. However, teachers need to have knowledge of mathematical patterning and be capable of capitalising on children's interests (Waters, 2004). The role of the teacher in questioning, providing resources, being involved, and offering encouragement has the potential to enrich mathematical patterning experiences and extend the children's existing knowledge. Further studies could provide greater insight into how teachers' knowledge and involvement could influence and enhance similar learning opportunities.

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