

PAPER PLATE PATTERNS: PRE-SCHOOL TEACHERS WORKING AS A COMMUNITY OF PRACTICE

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Young children's patterning, defined as 'finding a predictable sequence', has been identified as significant for later mathematical achievement, while proving amenable to amelioration. This study examines how English teachers of three- to five-year-olds engaged in a collaborative project designed to develop their children's pattern awareness. The teachers and researchers formed a community of practice that enabled the teachers to share and develop their pedagogical practice. This paper illustrates one example of how the teachers worked together to change their practice around border patterns; as their collaboration developed they produced interim stages in the teaching sequence that fostered children's reasoning.

INTRODUCTION

Recently pre-schoolers' pattern awareness has been identified as significant for later mathematical achievement (Rittle-Johnson, Fyfe, Hofer, & Farran, 2017). Fortunately, it can be taught, with positive effects relating to number and pre-algebraic thinking, which has particular relevance for low-achieving or disadvantaged children (Papic, Mulligan, & Mitchelmore, 2011).

Two years ago, we began a collaborative project with English teachers of three- to five-year olds, drawing on the work of Papic et al. (2011) and Mulligan and Mitchelmore (2016). In this paper we consider the following research question: How do teachers work together as a community of practice to develop their children's understanding of repeating patterns?

LITERATURE

Professional Development

In PME 42 Tirosh, Tsamir, Levenson and Barkai (2018) identified that pre-school teachers receive little preparation for teaching mathematics to very young children and that there is therefore a need for professional development in mathematics for this group of teachers. Although Tirosh et al. (2018) were discussing the Israeli context,

this need for professional development in early mathematics education is equally present in the English context (AAPG, 2014).

Many of the design principles that Tirosh et al. (2018) engaged in as they designed their professional development were the same as the design principles we used: playful learning, flexible activities, activities where the child is active but the teacher guides the child's learning, and objects that are familiar to the children and readily available to the teacher. Most of our teachers were trained in Froebelian principles and therefore child-led, playful learning was an important component of our design. We designed flexible activities and encouraged the teachers to adapt them to their own contexts using objects that were readily available in their classroom and thus familiar to the children. A difference with the design of our study and that of Tirosh et al.'s (2018) is that we engaged our teachers in the design of the curriculum and evaluation of the scope and sequence of the activities we proposed. Thus, we offered professional development in the model found to be most effective, by engaging teachers in curriculum development and evaluation (NCETM, 2009).

Repeating patterns

Patterns are composed of discernible regularity, whether a regularity involving repetition or systematic change. Mulligan et al. (2015) define a pattern as “some regularity observed in a mathematical context and the description of this regularity is its structure” (p. 1). Repeating patterns are the first type of patterns that are explicitly taught to children, often being introduced during preschool (Clements & Sarama, 2008). These patterns involve a unit of repeat, which is the smallest unit which when repeated makes the entire chain/surface/structure, for example, the pattern ABAB's unit of repeat is AB.

It is not clear why knowledge of repeating patterns should predict later mathematical achievement (Rittle-Johnson et al., 2017). Papic et al. (2011) argue that their project was effective partly because teachers encouraged children to look for structural similarities and differences. However, Threlfall (1999) pointed out that identifying the unit of repeat is key, as children can produce simple repeating patterns by visual matching or alternating actions, without understanding that it can be infinitely repeated. Papic et al. (2011) suggest that recognising a composite single unit which can be counted leads to multiplicative reasoning and functional thinking. Teaching about repeating patterns must therefore focus on the unit of repeat.

Border patterns are an extension of linear repeating patterns, because they add the complexity of changing direction and introduce the necessity of thinking of equal groups if the spaces in the border are defined (Papic et al., 2011). Our introduction of border patterns in our professional development addresses Tirosh et al.'s (2018) request that professional development for early years' professionals widen their understanding of what of repeating patterns can consist of.

THEORETICAL FRAMEWORK

Communities of practice is a social theory for investigating how people work and learn collaboratively (Bannister, 2018). Wenger (1998) identifies a community of practice as a group whose members are mutually engaged in an activity, have as joint enterprise and have a shared repertoire of customs of practice. Mutual engagement of the participants is an essential part of a community of practice, because there is no practice without participation. This mutual engagement creates “relationships among people” (Wenger, 1998, p. 76) that can result in deep interconnections. Joint enterprise is a goal that has been mutually negotiated by the members of the community but has not necessarily been reified as a vision or mission statement; as the community of practice evolves, the joint enterprise may evolve too. Over time, as the community works together, they will develop a shared repertoire of participation and reification structures. These shared repertoires may include routines, use of words, tools and ways of talking.

Wenger (1998) defines practice as “meaning as an experience of everyday life” (p. 52) and further defines meaning as located in the process of negotiation of meaning through the dual processes of participation and reification. Participation is the “experiential process of taking part and sharing in communities” (Bannister, 2015, p. 249), whereas reification refers to the “process of giving form to our experiences by producing objects that congeal our experience into ‘thingness’” (Wenger, 1998, p. 58). As we analyse what learning has occurred in our community of practice we need to examine both the participants' change in participation in the practices and any reification that occurs.

METHODOLOGY

Context and participants

This project extended over two years. In the first year we worked with six teachers of three- to five-year olds in four socially diverse state-funded schools in London, UK, which expanded to 11 class teachers in six schools in the second year, with five teachers continuing throughout. The schools had volunteered to join the project and the teachers were mostly highly experienced.

The teachers attended 14 after-school meetings, at which we offered a flexible core teaching programme, which we encouraged the teachers to adapt for their children and settings. At these meetings we provided a brief background to the research, introduced the next month's topic and the teachers shared how they had been teaching pattern. While four main areas of pattern were examined across the year, in this paper we focus on repeating patterns, in particular border patterns.

We also visited the schools three times each year to observe teaching and learning, to assess the children's pattern awareness and to discuss the children's progress.

Data collection

The data reported here derive from three sources: field notes from teachers' reports at project meetings and informal interviews, our observations of teaching and learning in schools, and semi-structured group exit interviews. Our findings rely on teachers' stated reflections on the progress made by children and what helped to develop this. We asked the teachers at each meeting to report on the children's responses and any progress the children had made in their pattern awareness. When we visited the teachers at school, we asked what had made a difference to the children's progress in pattern development and what they had struggled with. All teachers kept "learning journals" with photos relating to the children, which they discussed with us. More generally we asked how pattern had related to the children's mathematical development and, if positive, why they thought that. In the exit interviews we asked what impact the project had on the children and their teaching. We analysed our notes and transcriptions to identify common themes and conclusions in relation to our focus on learning in a community of practice.

FINDINGS AND ANALYSIS

Our group of teachers consisted of a community of practice in that they were mutually engaged in a joint enterprise and had shared repertoires for engaging in this community. This group consisted of early years teachers who were engaged in the joint enterprise of improving their young children's engagement in mathematics, through pattern activities. While engaged in this joint enterprise the teachers were mutually engaged in curriculum development in pattern instruction for the early years and refining the current developmental progressions. These teachers also had a shared repertoire in that they met every six weeks and at these meetings they had norms for sharing how they had implemented and adapted the programme.

As members of this community of practice, the teachers developed their subject knowledge about patterns and changed their teaching practice by developing several convergent pedagogical approaches, such as integrating patterning into whole class routines and encouraging children's independent "co-working", which included the children challenging each other to continue patterns or spot errors. These are all examples of the teachers' learning within this community of practice.

In this paper we will investigate one specific example of the teachers' learning within the community of practice, examining how they changed their participation in the practice of teaching their children about border patterns through the reification of paper plates. In Papic et al.'s (2011) original border task the children were asked to complete a 14 square border pattern when given two colours, identify whether the pattern has a beginning and end, and justify whether the pattern could be completed. This task presented young children with numerous challenges. Some children found the fine-motor task of fitting the blocks into the given spaces difficult and consequently ended up with an AB pattern that was not continuous around the rectangle (see Figure 1). Other children could make a linear AB pattern but had difficulties continuing the pattern around a corner (see Figure 2), while others came up with more innovative patterns, such as AABB, but were then frustrated when they found that their unit of repeat would not fit into the fixed number of squares (see Figure 3).

During the second year, Sam (all names are pseudonyms) reported that his children "made patterns with objects going round a paper plate, which gave them a template for a circle" and enabled them to make continuous circular border patterns (see Figure 4). The paper plates had several advantages over the rectangular border because on the paper plate there was no prescribed space for an object to be placed so children could squeeze another object in or adjust the spacing between the units to fit. The paper plate was the reification of an open circular border, with no corner to negotiate.



Figure 1: Blocks in spaces

Figure 2: Turning a corner

Figure 3: Unit of repeat



Figure 4: Paper plate

Figure 5: Mirror

Figure 6: Open rectangular border

The other teachers took up this idea in their practice and commented on it in subsequent meetings, with both Tina and Pam remarking that it is “easier to do circular borders than square” and that her children “enjoyed the circular patterns”. In this community of practice, the open circular border pattern had become an interim stage between linear repeating patterns and the rectangular border patterns proposed by Papic et al. (2011).

However, several teachers noted disadvantages in using plates and made further adaptations: for example, Pam said, “Dave wanted to put another circle inside the first one, maybe because he thought that he had to fill in the plate. He wanted to match the inside and outside circle but didn’t realise that the numbers couldn’t match. So I coloured the inside of the circle so that the children didn’t feel like they had to fill in the middle.” Kathy also found that the children tended to want to fill in the entire plate (see Figure 4), so she got her children to make a border around a circular mirror (see Figure 5). As the other teachers engaged with Sam’s practice they negotiated the meaning of the paper plate and adapted its form to meet their understanding of the purpose of the plate.

Kathy and Kim developed a further interim stage of making a border around rectangular frames, which involved turning corners, but without a fixed number of squares (see Figure 6). We observed two children fitting pom-poms around a rectangular border. At first the pattern was white, white, white, yellow, yellow, blue but there was an error where it joined up with itself, which they fixed, with some prompting, by adding more pom-poms. When we asked if they could remove some pom-poms because the border was “a bit wavy”, one child said, “I might change the pattern” and made it fit better by removing one yellow from every unit of repeat. The two children jointly described this pattern as “white, white, white-3 whites” and “...blue, yellow and start over and over”. The changes in their teachers’ practice and the reification of these changes (e.g. the open border with and without corners) seem to have enabled these children to analyse and identify the unit of repeat in a continuous pattern.

CONCLUSION

The early years teachers in this study worked together in a community of practice to improve their children’s engagement and knowledge of mathematics through developing curriculum. As they collaborated together and shared their observations and pedagogical innovations they also improved our knowledge of the developmental progression from linear repeating patterns to border repeating patterns.

As these teachers participated in the community of practice they realised that although their children found linear repeating patterns relatively simple, many children found border patterns more complex. One teacher came up with the idea that children found it easier to make a border pattern in a circle because this avoided the difficulty of going around corners, and he reified this innovation in the form of a paper plate. Other teachers in the group took up this idea and tried it out in their classroom, adapting the reification to address the new complications and to add further interim stages between linear repeating patterns and border patterns.

The strength of this community of practice lay in the participants' willingness to share and develop their pedagogy, which resulted in the teachers creating significant interim stages in the trajectory of developing pattern awareness. As a consequence of this group's work the current developmental progression between linear repeating patterns is: 1) linear repeating patterns; 2) circular repeating border patterns; 3) repeating border patterns around shapes that have corners; 4) repeating border patterns around shapes with corners and a defined number of spaces to fill.

The study shows that when early years teachers are given the opportunities to work collaboratively together in a community of practice on a regular, on-going basis, they may not only improve their own subject knowledge and pedagogical practice but may add to our understanding of how young children learn and develop mathematically.

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