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Young children's mathematising during free play with 'loose parts'

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'Learning through play' is an oft-quoted maxim for Early Years education. I was interested in investigating how free play with 'loose parts' (blocks, acorns, pebbles, etc.) might support children's experiences of mathematics. In this paper I discuss the first part of a study carried out with four 4-year-old children in Malta. The children were presented with various loose parts and allowed to play freely without adult intervention. I noted whether the children gave mathematical interpretations as they played; my main interest was numerical/quantitative interpretations. As a theoretical framework I drew on Vygotsky's theory of play and on the notion of 'mathematising' (Sfard), or participation in mathematical discourse. I considered this in terms of the relations set up by way of terminology (Walkerdine). My data showed that spontaneous mathematising during the free play was limited.

Keywords: Mathematics and play, early childhood education, mathematising; loose parts.

Introduction

As part of the recent Maltese National Curriculum Framework (Ministry for Education and Employment, 2012), the 'Early Years' (ages 3–7) has been recognised as a key period of education. The document emphasizes that the pedagogy to be used during this time should be distinguished from the more structured pedagogy used in the Primary years. In Malta, non-compulsory kindergarten education has been offered within State school settings since the mid-1970s, although, as Sollars (2018) explains, staff training, qualifications, recruitment and retention have posed challenges over the years. With the recent introduction of undergraduate training for kindergarten teachers, the hope is that over time, informal pedagogy will counter the established practices of formal literacy and numeracy sessions commonly carried out in kindergartens. My involvement in the new degree programme prompted me to carry out a study, in which I considered one type of play situation, namely invitations to engage with 'loose parts' (sets of items such as blocks, acorns, pebbles). My first research question was whether children would spontaneously give mathematical interpretations when playing freely with loose parts; I also asked if, and how, interpretations would be influenced when numbers were added to the sets of items available. A third question was how an adult's (myself) contributions could influence the children's apparent 'mathematising'. In this paper, I report on the first two questions.

Mathematics and play

Björklund (2016) conjectures that there is hardly any early childhood educator or researcher who would not argue for the value of children's play. However, May (2016) reflects on what 'learning through play' means, highlighting that early years educators are pulled between two 'poles' (p. 21), namely construction and instruction. While 'construction' emphasizes more freedom for the child to discover and create meanings independently, 'instruction' assumes a greater role for the adult in the learning process. Several studies that have been carried out in Early Childhood settings focus on

contexts wherein adult guidance is involved (e.g., Brandt, 2013; Sayers, Andrews & Björklund Boistrup, 2016). It is less common to find studies on children playing freely. One notable exception is Helenius et al. (2016), who use free play situations to theorize what renders play ‘mathematical’. Helenius et al. (2016) suggest that play is rendered mathematical if it is creative, participatory and if it includes rule negotiation. They thus place social processes in the forefront of their analysis and used these criteria to describe episodes of 6-year-olds’ play as being mathematical or otherwise. They distinguish their method from a more common approach to associate the mathematics of young children with school topics such as number, geometry, pattern or measurement. I myself have taken the latter stance in my study for three reasons: First, I was interested in quantitative dimensions of reality (van Oers, 2014) from the perspective of the child; second, ‘Numbers’ are stressed in our kindergartens, and third, I wished to focus on the use of subject terminology to complement my research in primary classrooms (e.g., Farrugia, 2017).

Helenius, Johansson, Lange, Meaney and Wernberg (2016) explain that the acknowledgment of the importance of the educator in Early Childhood education has led to questions about the kind of learning that children gain when ‘left to their own devices’ (p. 7). Indeed, Lee and Ginsburg (2009) note that early childhood mathematics is broad in scope and doubt that much of it will emerge in free play. Similarly, Clements and Sarama (2018) argue that ‘mathematical centres’ (classroom areas set up with materials that might encourage mathematical tasks) might promote some incidental learning, but rarely build one mathematical idea on the next, which is a key characteristic of this content area. My interest in studying free play is founded on my knowledge that such periods are common in Maltese kindergartens. Sollars (2013, and works in progress discussed in personal communications) studied a large number of local early childhood settings, and has noted a common pattern of adult-guided structured activities interspersed with ‘free play’ at various times of the day. Structured activities (hence, ‘instruction’ time) include painting and crafts, storytelling, and also worksheets aimed to fulfil school and parental expectations for learning to recognize and write numbers and letters. Free play (presumably ‘construction’ time) might involve the home corner, table-top toys, coloured dough, wooden puzzles and sets of ‘loose parts’ (e.g., blocks, sticks, pebbles).

My interest in focusing on play with loose parts in particular derives from the assumption that such items, being open ended, are intended to invite interaction and creativity. With regard to mathematics, Tucker (2010) suggests that they offer opportunities for counting, sorting, pattern making, operations, investigations into weight and length, and problem solving. I am aware of only one project that (in part) focused on mathematics and loose parts. This was carried out by Novakowski (2015), who worked with teachers to provide children with ‘Reggio Approach’ inspired provocations. However, most of the activities were set up with an intention in mind (e.g., a pattern with gems is displayed, prompting the children to explore patterns of their own, or the children are challenged to try stacking five pebbles). It is not my intention to argue that this type of play is necessarily more/less suitable than other types of play for prompting mathematical interpretations. Rather, my intention is to offer an original focus by reflecting on young children’s mathematising during free play with loose parts.

Theoretical framework

Vygotsky (1967) held that imaginary play had an enormous role in a child's development, in that it is a transitional stage through which a child can 'sever thought from an object' (p. 12). The liberating of thought and meaning from their origin in the perceptual field, provides the foundation for the further development of speech and its role in advanced forms of thinking. This liberation of meaning from object is facilitated by means of what Vygotsky referred to as 'pivots'. If a child uses a stick as a horse, the stick acts as a pivot to transition to the child from a real situation to an imaginary one. Vygotsky (1978) further explains that when using a stick as a horse, the child retains the property of the thing, but changes its meaning. It is the meaning, in play, that now becomes the central point and objects are moved from a dominant to a subordinate position. Indeed, Vygotsky believes that a key characteristic of play is that it is a stage between, on one hand, the purely situational constraints of early childhood and, on the other hand, adult thought which can be totally free of real situation. Just as Vygotsky recognised play items as pivots for more abstract and imaginative thought, in this study I view the 'loose parts' as pivots that offer potential opportunities for mathematical interpretation.

Working within a Vygotskian perspective, van Oers (2010) explains that an unintentional, or spontaneous, action/utterance by a child may be taken as a cultural form [e.g. mathematics] and reacted to accordingly by an adult; in time, through participation in such interactions, the child him/herself may acknowledge the [mathematical] meaning of the adult reaction, and finally, of his/her own actions as well. The mastery of new language develops through communications with other people, even in play contexts (Van Oers, 2010). Sfard (2008) refers to the participation in mathematical discourse as 'mathematising'. In her classic book, Walkerdine (1988) posits that a shift to mathematical discourse is a shift from one practice/system of signification (e.g. an 'everyday' activity) to another practice/system of signification (e.g. mathematics), wherein new relations are set up. For my analysis, I planned to focus on the children's utterance of words that indicated a mathematical idea, and also on apparent relations expressed through these words. Relations may have been expressed by way of language alone, or with reference to the play items. I believed that the expression of such relations would allow me to discuss (a) whether the children engaged with mathematics 'spontaneously' in their play (first part of study); (b) if, and how, my prompts 'pushed' the children in the direction of considering the play items from a mathematical perspective (second part). My main interest was number and counting, although other ideas may also have been noted.

Research design

The choice of school and classroom was opportunistic. I was acquainted professionally with the Head of School, who then put me in touch with a volunteer teacher who allowed me to work with her 4-year olds. I sat in the class a few times in order that the children and I become familiar with each other. Since the 14 children in the class came from varying language groups, the teacher used English as a lingua franca. This is a common language strategy used in Malta, where English is the country's second language. The four children who participated in my study were chosen by the teacher such that they would feel comfortable playing together. Parental consent and the children's

own assent were also necessary. Mario and Sarah were Maltese, Dorina was Hungarian and Ling was Chinese. All four children understood English; they could also speak English, with Sarah and Dorina being the more fluent. During the study sessions, I used English, although switched to Maltese if Mario chose to speak to me in Maltese. Their teacher reported that they all ‘liked mathematics and numbers’.

Eight 30 minute video-recorded sessions were carried out in the school library. Sets of ‘loose parts’ were prepared in boxes/dishes and the children were free to choose items to play with; a selection of the following items were provided on various days: acorns, small tree slices, sea shells, plastic coloured blocks, plastic coloured connecting camels, white and black river pebbles, gemstones, coloured foam dice. Numerals in various forms were introduced in Session 5. My main interest was number/quantity, but I was open to note other mathematical ideas that might arise. The children generally played around a table, sometimes moving to other parts of the room. For the first five sessions, children played freely, with minimal interaction from my part. Although the intention was not to intervene at all, in practice I found that simply watching without saying a word was unnatural; some interaction was inevitable. However, for Sessions 6–8, I interacted much more, and with purpose, as they played. In this paper I report on the first part, Sessions 1 - 5.

Analysis of the data was done by viewing the videos and noting where ‘mathematical’ vocabulary was used by the children. Short transcripts were produced of these excerpts in order to trace interaction (for example, to document if, and how, a child’s comment was reacted to by the others).

Results

The children played with the items eagerly. For much of the time each child was focused on their own task, albeit communicating with the others, and being influenced by the play going on around them. For example, if Dorina made a ‘necklace’ with connecting camels, the others picked up the idea and made their own necklaces, bracelets and crowns. At times Sarah and Ling played together. A lot of the play was imaginative and centred on the idea of birthday parties, an idea originated by Sarah. An element that persisted throughout all the sessions was making ‘cakes’ by filling the plastic dishes with pebbles and the other items. Pictures of children or monsters were sometimes placed in the dish to represent party guests; the table was sometimes decorated in various ways and the children sang ‘Jingle Bells’. The most popular items were the sea shells, gemstones and connecting camels. Figure 1 shows two cakes and a necklace.



Figure 1: Examples of children’s play creations

There were a number of comments relating to size and shape, and a high proportion of these were stated in the first session, when the children first saw the sets of items, for example “Oh! Tiny little shell!” (Dorina); “This is a pointy one” (Sarah); “This small one” (Ling). Not enough was said here

for me to be able to conclude that the children were operating beyond an everyday use of qualitative descriptions (Walkerdine, 1988), although Mario did express direct comparison, a first step to the quantitative aspect of measurement (“Mine is going to be bigger than yours”). In relation to shape, Dorina once said that her camel arrangement was a rectangle, and Mario commented “it’s oval” in relation to a shell. Hence, they applied names of geometric shapes to their play items, even if the labelling was imprecise. Occasions when *numbers* were mentioned were few. When the children first saw the monster pictures, and prompted by Dorina, they started commenting on the number of eyes (“One eye”, “two eyes” etc.); on two of the days, Dorina also selected monsters according to their eyes. In the first session, Ling pointed to the cameras saying “One, two.” At another point in the same session, Mario asked me why I had two cameras. These spontaneous uses of numbers were clear examples of quantification, and hence of these three children’s participation in the cultural practice of using numbers for expressing cardinality. It was interesting that quantity was alluded to more when a problem of limited number of each type of resource arose. Comments like “I don’t have enough of these” (Dorina), “But I need one of those!” (Mario) and other similar comments were heard, as children vied for the items they wanted/needed. The first time the problem arose this happened since we had limited space to work in, so I had to cut down on resources; then, the following day I limited the number of items purposely in order to confirm my observation. Mario and Sarah spontaneously indicated ‘emerging’ mathematical ideas relating to million as a large number, and half as part of a whole: “It was my birthday; it was a million birthdays” (Mario), “Hey Ling! You took half them!” (Sarah, referring to the gems) and “**Ghax jinkiser bil-half**” [**Because it will break with half**] (Mario, in relation to a delicate shell). On the other hand, I had included a set of foam dice to offer an opportunity for the children to focus on the dot arrangement, perhaps to subitise. However, the children used the dice as part of the cake decoration, or to construct a tower. Dorina mentioned that she had once had ‘one like this’ (a die), had lost it, and now had a new one. Although generally I was not intervening in the sessions, I pointed to the spots and asked Dorina if she knew what they were, to which she answered, “Yes, spots”. Thus she gave an everyday interpretation of the spot pattern, and did not spontaneously subitise.

On the fifth day I introduced numerals (1–10): a set of large red/blue/yellow plastic numbers, a set of magnetic numbers and cards with pictures of balloons printed on them. Dorina showed an interest in them immediately, crying: “Numbers!!!” She took magnetic numbers and laid them out in order on a metal sheet pointing to each one and naming them: “one, two, three ...” The relation between the positioning of the tangible numbers and the recitation of the names illustrated that Dorina could engage in the practice of counting using the one-to-one and stable order principles (Gelman & Gallistel, 1986). She proudly showed up the display to the others, but they showed no interest, continuing with their own activities. Dorina then moved on to making a necklace with the camels. Similarly, Mario started the session by looking through the large numbers, naming some of the them as he did, thus giving evidence that he could ‘name’ the items appropriately; however he very quickly lost interest and turned to the box of camels instead to make a crown and other things. Ling showed evidence of being familiar with the cultural practice of putting a number candle on a birthday cake: she placed a number 4 on her cake, stating “I’m four year”, then placed other different numbers on the other cakes. I consider this to be evidence of an ‘emerging’ mathematical

idea, since although the symbol was used appropriately in relation with the 'cake', it is unlikely that such a young child would have a conception of the time measurement of '4 years'.

Other uses of the number items were non mathematical, for example as when Dorina grouped them by colour, placed them in different dishes and stated "I am making pies of the same colour"; Ling and Sarah used the magnetic numbers as they did the pebbles, acorns, etc., that is, to fill a dish to create a cake. When I asked Ling why she had put 'these new ones [items]' on top of her cake, she answered "because this number cake"; in previous sessions she had made a 'birthday cake' and a 'rainbow cake'. Sarah used the large plastic numbers as decorations around the cakes, as she had used the children/monster/balloon cards. At the end of the session, having exhausted all the items except the magnetic numbers, Ling and Sarah turned to these items and used them to 'draw' what they called a number castle (that is, a castle drawn with the numbers).

Discussion and conclusion

Prior to the study, I had anticipated that the children might spontaneously engage with mathematics in general, and number in particular. This assumption was based partly on the fact that at school they were systematically learning the numbers and their values, and partly on research and pedagogy texts (for example, Seo & Ginsburg, 2004; Charlesworth, 2012 respectively) that mention how children 'spontaneously' engage with mathematical ideas. However, in my small study I noted limited spontaneous focus on ideas that I might classify as 'mathematical'. That is, mathematical terminology was used only a little, and not necessarily in a way that implied mathematical relations (Walkerdine, 1988). In the absence of certain relations, one cannot conclude that the children were 'mathematising'. Even when prompted with numbers, the children's attention to the quantities related to these numbers was limited. Since I had seen large dice in the classroom, one with numerals and one with the spot pattern, I introduced the dice to prompt subitising, but these were used as blocks or decorations. Hence, following Helenius, Johansson, Lange, Meaney and Wernberg (2016) and others, I too query the amount of mathematics that children engage with when left to play freely, although it is worth noting that restricting the number of resources increased talk related to quantity/number. There was some evidence of 'emerging' mathematical ideas, such as when the children used discipline-related words in an approximate or referential manner. This is similar to when the children use grammar rules in an inappropriate way. Examples of the latter are when Ling said to Dorina "You broke-ed them" or Mario said "**Ajma, subajji**" [**Ow, my finger**]. In both cases the child was applying a general grammar rule (shown here underlined) which did not actually apply to the word being used. Still, as an adult I recognized the emergence of language rules that, presumably, the child was appropriating through social interaction over time. From the perspective of mathematising, 'emergent mathematics' might be viewed as the crossing of boundaries (Walkerdine, 1988) from one practice (everyday experiences and ways of expression) to another (school mathematics).

One possible explanation for the limited mathematising might be found in the children's classroom experiences. The class teacher had explained that she targeted mathematics (mainly numbers) through daily routines (e.g. counting children present) and storytelling (e.g. counting the fruit the hungry caterpillar ate) and also through worksheets focusing on number recognition and quantities

which were expected to be carried out. While the children were regularly given periods of free play (house corner, table top toys, puzzles, sets of loose parts and so on), the teacher admitted that during such time she did not interact with the children but tended to use the time to catch up with required paper work, to set up an activity, disinfect toys or to sit with individuals to help them through a worksheet (numbers / letters). It seems that the mathematics they were learning in the structured curriculum remained distinct from their play. Another reason may have been that from the children's perspective, there was no 'need' or interest to count items or to engage with the numbers provided in a mathematical sense. Rather, the tasks of (mainly) making cakes and joining up camels took over the children's attention almost completely. Although the children initially admired the pebbles, etc. and the numbers, ultimately, the use of all items appeared to be subordinated to the main task of interest, e.g. filling a dish to make a cake, 'drawing' a picture and so on. This may have been compounded by the fact that many of the items provided were novel and caught the children's attention/imagination.

Vygotsky (1967) has written about the development of abstract thought through free play; he theorises how meaning becomes central, while objects themselves are moved to a subordinate position. There is still much to be done in exploring the transition from a play situation to one where play items are given an abstract 'mathematical' interpretation. That is, focusing on the numerical/quantitative aspect rather than, for example, on the item's potential use in the creation of a cake. In the second part of my study, I made a systematic attempt at using the play items as 'pivots' for mathematising. My initial analysis (still to be reported) supports the argument that purposeful intervention can be effective for prompting a focus on mathematics. According to Walkerdine (1988), this focus involves creating new relations, even when using lexical elements already familiar from 'everyday' (hence different) experiences. In the context of free play - where children rightly assume a freedom to play as they please - the process is a challenging one.

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