Active learners in numeracy: implementing guided play for early numeracy learning

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ABSTRACT

Reception teachers frequently report a tension between the development of children's academic knowledge and skills and that of the prime areas of learning (communication and language, personal, social and emotional development and physical development). This is particularly pertinent when considering support for children from disadvantaged backgrounds, who are often adversely affected by environmental factors. Play-based pedagogies, such as guided play, have the potential to address this tension; however, further practical guidance is needed on implementation. This action research project sought to develop a research-informed approach to implementing guided play in the teaching of early number concepts, which, simultaneously, addressed the prime areas of learning with a focus on physical development. A toolkit of activities and resources was developed and delivered in five schools, for 150 children. Naturalistic observation data was gathered from teachers from each school. Key observations are shared that explore how children's number sense develops through multisensory and socially interactive approaches. An evaluation of the practical limitations of the project offers insights that may support other teacher-researchers.

KEYWORDS

SOCIO-ECONOMIC DISADVANTAGE

GUIDED-PLAY

NUMBER

PHYSICAL DEVELOPMENT

1. INTRODUCTION

1.1. Early years education for children from disadvantaged backgrounds

During the first five years of human life, the brain is highly sensitive to environmental influences including the quality of interaction provided by caregivers at home and early childhood education (ECE) settings (Sylva *et al*., 2004, 2010, 2015; Sirois *et al.,* 2008; Taggart *et al.,* 2015; Melhulish & Gardiner, 2018, 2020). A stimulating early environment supports the growth of firm foundations in cognition, language and executive function (EF) skills, predictive of later educational and wellbeing outcomes (Howard & Melhulish, 2017). In the UK Early Years Curriculum (DfE, 2021), the importance of these firm foundations is reflected in the designation of the three Prime areas of Learning as Personal, Social and Emotional Development; Communication and Language and Physical Development alongside the Characteristics of Effective Learning. However, children from socio-economically disadvantaged homes, typically, have less frequent and less rich interactions with caregivers at home, are the least likely to attend ECE settings and often begin their school life in Reception behind their peers (Sylva *et al*., 2004, 2010). Reception is,

therefore, a uniquely important year for addressing inequalities and supporting strong foundations for learning. Significant longitudinal studies of ECE settings for children aged three to five found that the most effective settings prioritised the Prime Areas of Learning through play-based pedagogies that were beneficial for all children, and particularly effective in supporting children from disadvantaged backgrounds (Sylva *et al*., 2004, 2010). However, despite the recognition of the significance of foundational aspects of learning (Ofsted, 2017, 2022), teachers of young children in the UK are working in systems that pursue national benchmarks for academic attainment to ensure 'school readiness' (Ang, 2014). This generates a focus on academic skills development and often leads to didactic and instructional approaches to teaching in order to meet the 'early learning goals' at the end of the Reception year (Brogaard Clausen, 2015). As a result, practice tensions emerge regarding the type, nature and content of teachers' interactions with pupils.

1.2. Guided play

Guided play is a pedagogical approach that combines the benefits of free play alongside the value of direct instruction through interactions that incorporate adult-scaffolding with child-directed learning (Weisberg *et al*., 2013). In this sense, it can be described as a 'hybrid play pedagogy'. Guided play creates a 'co-constructed, play-based environment' that is rich in adult–child interactions (McInnes *et al*., 2013). Walsh *et al*. (2010) suggest that adults can remain in control and guide children's learning in a playful way. The socially oriented and flexible nature of this approach can support both foundational development and academic learning such as numeracy (Zosh *et al.,* 2017). Guided play is supported by advancements in neuroscience (for example, Goswami & Bryant, 2007), which further emphasise the interconnected and holistic nature of development and support play-based pedagogies that are multisensory, emotionally engaged and interactive. However, whilst guided play presents a theoretical solution to tensions between academic and foundational priorities in ECE, further research in naturalistic settings is needed to support teachers in the practical implementation of this approach (Weisberg *et al.*, 2016).

2. ACTION RESEARCH

2.1. Motivation

Against this backdrop, the present action research project responded to the practice-based tensions of Reception teachers from the Brixton Learning Collaborative (BLC) – a teacher network for pedagogical development – in Lambeth, London, in, 2017. Set in a community of high socio-economic disadvantage, children were typically entering Reception below age-related expectations in the Prime Areas of Learning. Teachers in the research group felt torn between giving children the adult-led input required to meet the then current early learning goals in maths (Development Matters, 2012), and time supporting children's development in the Prime Areas of Learning through play. The BLC gained funding from Shine, an educational charity committed to addressing disadvantage through teacher innovation, to design an 'Active learners in numeracy' (ALN) programme, which was delivered and evaluated in five reception classes. School-based action research involves teachers as 'co-researchers' in a process of self-reflective enquiry, where they deliberate and respond to school-based problems (Wilson, 2013). The participatory nature of action research was well suited to this project 'because of its commitment to involving people in the diagnosis of, and solutions to, problems, rather than imposing on them solutions to predefined problems' (Bryman, 2012). In this case, the question was to explore whether guided play could be implemented to resolve the tension between play-based approaches for foundational development and instructional approaches for academic achievement in maths.

2.2. Design

A pedagogic model for the implementation of a guided play approach was developed through iterative cycles of action research that could be shared (Stenhouse, 1975). In the first stage, the ALN research group reviewed literature surrounding themes of maths and physical development. In the second stage, this research was put into practice by developing the ALN approach and toolkit of resources through a piloting phase, in the lead school, for six weeks. In the third stage, a training session with proposed activities and resources was shared with participating teachers from the BLC. ALN was delivered in five Reception classes, over six weekly sessions and its impact was observed and evaluated.

2.3. Data

The main method of data collection to evaluate impact was naturalistic observation. These observations were captured through unstructured interviews with teachers after each week of practice and supported by pre- and post-programme questionnaires completed by all participating teachers.

2.4. Participants

The ALN approach was implemented with children and their teachers in five Reception classes of 26–30 children, aged four to five years, from the participating Lambeth primary schools within the BLC. In the lead school, 62% of the 26 children were receiving Pupil Premium. The other participating schools, in close geographical proximity, had a similar demographic make-up. As ALN was being conducted as part of the curriculum; the consent of teachers and headteachers was sought as the responsible guardians for children during school time. Parents were kept informed by a newsletter and were invited in for a morning to observe and participate with their children during the final week of the project. BERA ethical guidelines (2011) were considered, and due attention paid to the dual role of the action researchers as teachers.

3. ACTION RESEARCH STAGE 1: LITERATURE REVIEW

3.1. The context

The areas of maths and physical development were chosen as foci for two reasons. First, the teachers were feeling pressure to spend time on adult-led teaching of maths, in which children's enjoyment often seemed limited and children sometimes asked 'can I go now?', with a view to returning to play outside with their friends. Often, children would struggle to sit on chairs or manipulate objects and would present a need to move their bodies. In addition, engagement in independent maths learning was low, with children rarely accessing the indoor maths area independently, or using resources in the adult-intended ways, limiting time for rehearsal and application of their adult-instructed learning. Second, these were both areas in which practitioner confidence was lowest and therefore, the project was seen as an opportunity for continuing professional development (CPD). Practitioner confidence and knowledge of early mathematics has typically been low, compounded by limited professional development opportunities (Sarama & Clements, 2009; Boyd *et al*., 2014; Deans for Impact, 2019). Similarly, physical development is, typically, viewed as marginal and incidental and similarly lacking in meaningful CPD (Tsangaridou, 2017).

Recent research into neurological development suggests connections between physical development and learning in maths, with potential long-term effects for children facing disadvantage. There is increasing evidence to support a link between neuro-motor development and necessary capabilities for academic learning; namely the ability to listen, to process visual information, to manipulate physical objects with control, to focus attention and to sit still for short periods of time (Goddard-Blythe, 2010, 2012; Archer & Siraj, 2014). These abilities depend, in part, upon underlying foundational physical development, such as the integration of neuro-muscular reflexes, the vestibular (balance) system and gross and fine motor coordination. Goddard-Blythe (2005) suggests that many children come to school without these foundational physical abilities, especially those who may not have access to the space and nourishment for healthy physical development. These neurological foundations of physical development are also central to the development of executive functions (EFs), commonly grouped as: cognitive flexibility and attention shifting, inhibitory control and working memory (Diamond, 2000). Research indicates that children from disadvantaged backgrounds arrive at school with lower EFs and this is associated with lower achievement (Center on the Developing Child at Harvard University, 2011). A developmental association between physical development and EFs has also been found in the teaching of maths, where strong evidence suggests a mutually beneficial relationship when children are appropriately challenged in both domains, within a meaningful context (Clements *et al*., 2019; Scerif *et al., 2*023). For instance, a simple number problem to be solved in pairs may involve a child needing to hold a number in mind for a short time and apply that information (working memory), finding a different solution if this first attempt doesn't work (attention shifting and cognitive flexibility) and waiting and taking turns with a partner (inhibitory control) (Clements *et al*., 2019).

When considering mathematical foci for children in the Reception year, research suggests the importance of deep development of early number concepts or 'number sense' and applying this knowledge within practical activities. Number Sense is underpinned by counting, cardinality, composition and comparison (Sarama & Clements, 2009; Griffiths *et al*., 2016) with the importance of recognising equivalence and relative magnitude. Subitising has also been found to be particularly supportive of children's long-term success in maths and supportive of being able to view part–whole relationships (Gifford, 2010). Adult-led input is needed to support children's understanding of number; however, learning is more effective through play-based approaches (EIF, 2018), pretend play, and those that are creative and stimulate curiosity (Cremin *et al*., 2015). Further, the non-linear nature of learning requires repetition in varied contexts that allow connections to be made between experiences (Wortherington & Van Oers, 2016). In addition, research emphasises the importance of rehearsing language, and communication of mathematical thinking, both verbally and through informal mark-making (Carruthers & Worthington, 2004, 2005). Maths and physical development, therefore, represent an ideal focus for hybrid, play-based pedagogies with the ability to impact on children's learning across different, interconnected areas of learning, with particular benefit for children who have experienced disadvantage.

4. ACTION RESEARCH STAGE 2 – FROM LITERATURE TO PRACTICE: DEVELOPING THE ALN TOOLKIT

Building from this literature, the goal was to develop a movement-oriented, language-rich approach to guided play in numeracy learning. Pedagogical activities were divided into two areas: 'Physical Tune-up' and 'Maths through Movement'. The Physical Tune-up consisted of activities designed to 'wake up' the body's vestibular, proprioceptive and coordination systems, to prepare children for learning. It was designed to take place every morning for 15 minutes. These activities were drawn from pre-existing research-informed movement programmes such as the Institute for Neuro-physiological Psychology (INPP) (Goddard-Blythe, 2010) whilst also embedding key numeracy concepts. A video resource was created that could

be shared, so other teachers could play, and gradually, learn the routines alongside the children.

The Maths through Movement activities focused on addressing specific learning objectives in numeracy and integrating them into play-based, narrative-led, language-rich activities within an outdoor obstacle course. Two puppet parrot characters 'hooked' the children in and provided a narrative-based purpose and context; children were asked to complete both maths and physical challenges to get safely through the 'jungle' and help the parrots by solving a changeable mathematical problem at the end. Here they would need to manipulate concrete resources, such as sharing fruit, and communicate their findings at the 'communication station', providing opportunities for mathematical explanation and reasoning by role-playing a conversation with the puppets. They were also asked to represent their findings with mathematical marks on blank paper on clipboards and 'post' them to the puppets. The changeable mathematical challenge allowed for a specific aspect of the, then current, Early Learning Goals (DfE, 2012) to be taught, which included learning objectives unsupported by research (Gifford, 2014; Lyons *et al*., 2014;) and no longer present in the curriculum (DfE, 2021). The challenges that were a permanent feature of the obstacle course were those most effective in supporting children's number sense. These could be adapted, to vary the level of mathematical and EF challenge provided. Plans for each challenge, and how to expand week by week, were shared with the practitioners. A summary of the content of the maths lesson plans is provided in Table 1, where extensions appear in italics. Table 2 indicates physical challenges that were interspersed with the maths, signalled by a simple visual aid. The resources required for ALN are detailed in Table 3. The obstacle course remained set up for children to access during freely chosen learning time.

Table 1. Summary of activities from lesson plans focusing on maths with physical development opportunities

Activity name	Activity details	Mathematical learning	Physical
Collecting treasure	Roll dotted dice (can increase amount) Count the corresponding amount of treasure and put it in a bumbag.	Subitising (perceptual or conceptual). Counting quantities of increasing amounts. Compare who has more/ less/ equivalence with the partner's amount.	Fine motor – picking up treasure with fingers/ tweezers. Running after dice and
Crossing the bridge	Create a bridge (five frame/ tens frame) on the floor in chalk. Put some beanbags on the bridge in one colour. The bridge is broken – how many do we need to fix it and make it safe to cross?	Count with one-to-one correspondence. Recognise or calculate number bonds to 5/ 10. Vary the amounts and expand through questioning. Show on fingers the amount of planks that are safe to cross and those that are not.	Tiptoe over the bridge, stepping on the beanbags.
Crossing the stepping stones	Write numerals in drawn circles in chalk on the floor for children to jump to the correct next number in the sequence.	Recognise simple numerical sequences and patterns. Vary sequences – forwards/ backwards/ starting and finishing number. Add in red herrings so children have to chart their own path/ missing numerals for children to say themselves.	Jumping or hopping onto the numerals.
Bananas in the tree	Recognise numerals (supported by numerals in the tree) and throw beanbag at it – saying the correct number aloud.	Recognise numerals. Change the rules so that children have to say one more than or one less than the number.	Bending down. Throwing, aiming.
Communi-cation station	Solve a number-based problem and communicate to Crackity Jack and Cheep Cheep using pretend telephone and draw to support communication on blank paper attached to a clipboard. Variable challenges linked to Early Learning Goals including sharing/ doubling/ halving fruits for Crackity Jack and Cheep Cheep.	Mathematical reasoning and explanation. Mathematical mark-making – draw a picture to help explain the findings to Crackity Jack and Cheep Cheep. Doubling, halving, sharing etc.	Fine motor control – using a broad felt tip/ pencil to draw marks.

Table 2. Summary of activities from lesson plans focusing on physical development

Transitional activities	Activity details	Physical development
Jungle vine	Balance along a bench or line. Heel–toe walking.	Balance Proprioception
Lizard	Crawl along the floor on front, alternating left and right arms, opposite legs.	Bilateral integration Gross tactile stimulation
Cockerel	Balance on one leg with hands above head.	Balance Core strength Proprioception Gross motor coordination
Frog	Frog-jump across a mat.	Balance Core strength Gross motor coordination
Slug	Lying on back, move body head-first by pushing legs.	Core strength Gross tactile stimulation
Log roll	Lying on back, roll sideways along the full length of the body.	Core strength Gross tactile stimulation
Spider walking	Walk on hands and feet, body facing up, without bottom touching floor.	Balance Core strength Gross motor coordination
Bear walking	Walk on hands and feet, body facing down.	Balance Core strength Gross motor coordination

Table 3. Resources required for implementing ALN

- Puppets (we used large and small parrot)
- Giant dice (preferably with pockets to change amounts)
- Baskets to put things in (eg beanbags, treasure, numeral cards)
- Treasure
- Bench/chalk line
- Mats
- Giant chalk to draw bridge (giant tens square), stepping stones (number sequences etc)
- Printed banana numerals
- Numeral cards
- Beanbags
- Telephone sets (make with string and cups)
- Bumbags/treasure bags
- Hula hoops for banana-throwing target
- Tweezers to pick up treasure
- Cones/chairs to stick movement signs onto
- Clipboards/writing tools/for children to use at the communication station
- Pretend postbox

The changeable challenge would be introduced on the carpet to all children, including playful direct teaching and modelling. The jungle obstacle course set up outside (Figure 1), with three sets of resources, would, then, be completed in groups of six. The adult would, first, playfully model the learning involved in completing the course. The children, then, worked in pairs to complete it, allowing for continual development of communication and language and social skills as well as numeracy learning through rich interactions with peers, and the teacher sensitively supporting and questioning. Children were required to take turns, share resources and wait for one another, overlapping with EF challenges throughout. For instance, children would have to inhibit the urge to move ahead without their partner or take more than one turn. They would also be required to hold a number in mind relating to their partner's turn, or when rolling dice, requiring working memory. Similarly they would have to exercise cognitive flexibility in taking account of their partner's ideas, or when their first attempt to solve a problem was not successful, or when the rules of an activity were adapted, to provide increasing mathematical, and EF, challenges.

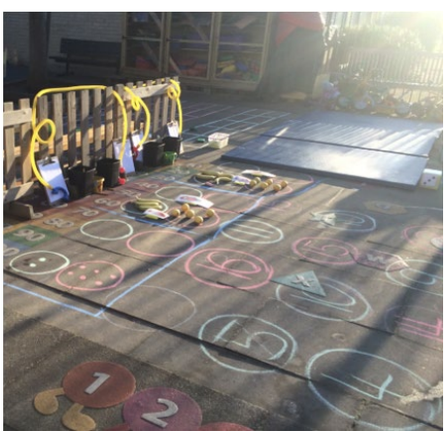

Figure 1. Photo exemplifying the jungle obstacle course set up outside.

5. ACTION RESEARCH CYCLE 3: OBSERVATIONS OF IMPACT

5.1 Key observations relating to children

Independent play

'I saw children making up their own number games.'

The maths jungle was set up outside and left out for continued use throughout the day. Teachers observed that some children would continue their learning without any adult supervision, replaying existing activities and inventing new ones. This demonstrated children's motivation to learn in movement-oriented ways and to explore their own mathematical ideas.

Number sense and multisensory approaches

'Some of the children who struggle to engage with number in the classroom are really benefiting from the multisensory approach [of ALN].'

Teachers observed an improvement in number sense and engagement in maths, particularly for children who came to the programme with lower attainment and enthusiasm for numeracy in 'the maths area' in the classroom.

Communication and language

'At the beginning of Reception, D was extremely shy, rarely speaking and often unable to ask for help. Through partner work, D began to find his voice, offering opinions on how to solve a number problem and explaining his thinking around a variety of solutions.'

The collaborative and interactive approach was observed to support children in their communication and language skills, especially children from disadvantaged backgrounds such as D.

Social skills

'The turn-taking really caught on. If a child was not waiting for their partner, other children would step in and remind them to wait or help.'

Teachers noted how much the children responded to adult modelling and praising of turn-taking, and applied this with increasing independence with frequent practice.

5.2 Key observations relating to adults

Training on how to do maths 'big and outdoors'

'Going outside and doing maths has been something new. It's not something we've really done before.'

Teachers recognised the programme as a form of practice-based CPD. For some teachers, this was an exemplification and a reminder of what they considered to be good practice, whilst for others, it was regarded as innovative. Teachers valued the open-ended nature of the resources (for example, chalk) and activities (for example, with number frames) and the mode of delivery (narrative-based), which they were able to use to address a range of different learning objectives

Awareness of physical development

'The Tune-up helped with their overall flexibility and stamina.'

Teachers observed improvements in stamina and balance in their children in the daily Tune-up. It was also noticed that the teachers, increasingly, discussed physical development in relation to the children's learning as the programme progressed.

Supporting parents with maths

'I've been using the "counting on with fingers" method at home after I came in and watched you do it.'

Parents who came to visit the open afternoon observed teachers reinforcing understandings of number within guided play and found this supportive for their parenting.

Practical constraints

'It's what we'd love to do if we had time.'

There was a broad consensus that teachers lack the time to deliver learning experiences such as the ALN programme. Firstly, additional time was needed to set out and put away additional learning resources. Secondly, outdoor and collaborative learning takes more time in terms of organising the children into groups and moving to an outdoor space. Thirdly, the flexible and responsive nature of the guided play pedagogy means that it is less easy to adhere to tight timings for working with multiple groups. It was noted that involving teaching assistants (TAs) in the project would have supported implementations beyond the end of the project.

6. EVALUATION AND REFLECTIONS

This action research project explored the implementation of a guided play approach to the teaching of early numeracy, in a way that supports children's physical development and other prime areas of learning, in order to address inequalities associated with socio-economic disadvantage. A key success of the programme was the implementation of guided play, where adults were permitted to teach (Walsh *et al*., 2010). Levels of engagement in numeracy learning with the adult- and child-led play were both positively impacted upon, with children continuing to engage in maths after adult direction. Through guided play, teachers were able to design learning environments that supported children in developing understanding of number concepts, drawing upon collaboration, character-based narratives and multisensory engagement. ALN provided an explicit focus on relevant learning outcomes, whilst, at the same time, giving space for children's individual needs and interests to be supported. Teachers developed a structured approach, from modelling interactive learning to

children, to children practising this in pairs with the adult, towards independent practice. This project provided a model for considering the holistic nature of learning, whereby physical development, social development, communication and language and EFs can be supported simultaneously.

ALN offers a demonstration of how action research can be an effective way for teachers to address tensions in their practice in an empowering way. Teachers felt more inclined to experiment with innovative approaches because they had come from within the BLC, rather than being implemented in a 'top-down' model. Teachers felt a sense of agency in meeting the needs of their pupils through creative problem-solving. There was also a recognition that action research can act as a form of training or CPD. This was reflected by improved knowledge and awareness of how to support children's physical development and why this is important as well as how to do maths 'big and outdoors'. However, some weaknesses in the approach were identified. With respect to the time and labour involved in the implementation of the project, we recognise that TAs were not included in the project, due to not allocating funding for the TAs to attend the CPD. If we were rerunning the project, we would plan to involve all adults, which may partially address time constraints involved in setting up and teaching through ALN. In addition, we would adopt a menu-style approach to the implementation, where teachers could select activities more fluidly, with the opportunity to shorten the obstacle course or use activities in isolation that could be led by teachers or TAs. This more flexible approach would support implementation without the additional adults from the research team.

Overall, this research provides an example of how guided play can be implemented as an approach to teaching early number, in order to provide quality adult instruction and rich, contextualised, playful learning that impacts positively on engagement in maths and supports holistic and foundational aspects of learning. ■

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