Early Years practitioners' training, beliefs and practices concerning mathematics: Implications for education and practice

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Abstract

The early years learning environment is vital for young children's learning and development. This study reports, for the first time in the UK, an online survey of 83 early years practitioners' perceptions, classroom practices, and beliefs towards mathematics. Surveyed practitioners rated life skills and literacy as more important than mathematics. They reported implementing activities focused on literacy in their daily classroom routine significantly more frequently than mathematics. Mathematics activities were typically formal, despite the belief that children learn mathematics best through play. Finally, early years practitioners' confidence and beliefs towards mathematics were associated with overall frequency of and perceived importance of mathematics in the early years, respectively. This highlights the need to enrich early years practitioners' awareness, knowledge, and confidence surrounding early mathematics to improve provision and raise attainment. This has important implications for addressing potential challenges as part of current proposed changes to the framework guiding early years practice.

Keywords: Early years, teacher perceptions, mathematics, continued professional development, classroom practice

Introduction

Early mathematical skills fostered during preschool are essential for children's later educational success (Clements and Sarama 2009), and more so than early reading and attention (Duncan et al. 2007 but see Bailey et al. 2020). Strong mathematical skills are also important for later health outcomes, and economic and employment opportunities (Bynner and Parsons 2006; Gross, Hudson, and Price 2009). Young children who begin formal education with low mathematical abilities are significantly more likely to remain low achievers throughout primary school and beyond, compared to their higher attaining peers (Aubrey et al. 2006). Children from low socio-economic backgrounds and children who have English as an Additional Language are also at higher risk of low attainment in mathematics, relative to their peers (Anders et al. 2012; Denton and West 2002).

High-quality early years education can be defined as learning environments that include a broad range of activities (e.g., literacy, mathematics, outdoor play) and programme structures (e.g., free play, small group and whole class activities), as well as opportunities for interactions and communication with adults and peers (Sylva et al. 2011). It plays an important role in addressing some of these inequalities in mathematics achievement, as the impact of early years learning environments on mathematical outcomes can still be observed many years later (Melhuish et al. 2013; Sylva et al. 2010). To further support early mathematical development and learning, research and policy have often called for an increased focus on mathematics in early education (All Party Parliamentary Group 2014; Pitchford et al. 2016) and effective, evidence-based interventions (Butterworth, Sashank, and Laurillard 2011; Jordan and Levine 2009). In contributing to this effort, for practitioners to successfully implement new interventions, they need to believe in the importance of such practice (Rogers 2003). Indeed, as outlined by Ernest (1989), mathematical education is influenced by teachers' knowledge, their beliefs around the importance of mathematics and their own attitudes towards mathematics. As such, it is fundamental to understand early years practitioners' perceptions, classroom practices, and beliefs towards early mathematics.

Importance of the Early Years Learning Environment

The quality of the early years learning environment is a complex concept including multiple dimensions, such as structural characteristics of the environment (e.g. staff qualification level), practitioners' beliefs and orientation towards learning processes (e.g. practitioner disposition), and the process quality of interactions between practitioner and young children (e.g. specific stimulation in areas of literacy or mathematics; Pianta et al. 2005). Research shows early years learning environments rated as high-quality have a significant impact on children's mathematical attainment during the first year of primary school at age 5, beyond other influential predictors, such as socio-economic status and ethnic and language background (Anders et al. 2012; Lehrl, Katharina, and Rossbach 2016; Sammons et al. 2004). It also longitudinally predicts mathematical development at the end of primary school when children are aged 11. But early years learning environments rated as low-quality did not have the same impact (Sylva et al. 2010).

Early Years Practitioners' Beliefs about Mathematics

Early years practitioners' classroom practices are influenced by their beliefs and values, such that their choices about which activities to implement are strongly associated to their personal beliefs about appropriate learning content and pedagogy (Brown 2005). Interestingly, practitioners' beliefs are shown to be more influential on their classroom practices, compared to subject knowledge they may have (Pajares 1992). A review of previous studies shows that educational practitioners view mathematical abilities as important for children's later maths development (Ginsburg, Lee, and Boyd 2008). Yet, prospective and practicing early years practitioners consider fostering young children's socio-emotional and language skills as more important compared to mathematical and other cognitive skills (Simpson and Linder 2014).

In addition, prospective early years practitioners have also reported more confidence in teaching reading and other language-related skills compared to mathematics, with the view that teaching early mathematics is difficult (Banilower et al. 2018; Copley 2004). Prospective early years practitioners also report high levels of mathematical anxiety (Bursal and Paznokas 2006), a lack of knowledge about early mathematical teaching methods (Bates, Latham, and Jin-ah 2013), and reduced mathematical subject knowledge (Perry, Dockett, and Harley 2007). Yet, there is wide variability in

the early years workforce and not all early years practitioners are afraid of maths (Artemenko et al. 2021). Teacher training program interventions that target practitioners' knowledge and awareness of mathematical development have shown positive impacts on reducing their anxieties towards mathematics (Gresham 2007). Research shows early years practitioners' positive attitudes towards mathematics, as well as their teaching experience, predicted their ability to recognise and implement mathematical concepts in play-based learning environments, which in turn enhanced young children's mathematical thinking (Anders and Rossbach 2015; Lee 2017).

Informal and Formal Classroom Practices

Early years learning environments typically follow play-based pedagogies through a combination of adult-led and child-initiated activities (Department for Education [DfE] 2017a). Informal learning activities are characterised by discovery-based learning (Baroody and Li 2009), which is often self-regulated, and child directed (Gray 2015) and can be assisted by the teacher (Zosh et al. 2018). For example, playing card games, dominoes, or finding mathematical concepts in the environment. In contrast, formal learning activities are typically teacher-led (Ginsburg, Lee, and Boyd 2008). For example, explicit practice in reading, writing, and reciting numbers. Despite long-standing debate in education about how children best learn in the preschool environment, both instructional approaches have been shown to positively impact children's early mathematical development (Fisher et al. 2013; Ramani and Siegler 2008).

Choices on the implementation of informal and formal learning activities have been shown to differ across subject domain. Early years practitioners reported implementing literacy during the core learning time using formal learning activities. Whereas, they preferred to incorporate mathematical activities into informal classroom routines throughout the day (Lee and Ginsburg 2007). However, there is a mismatch between the amount of time dedicated to mathematics stated in planning and what is actively implemented (Stephen and Wilkinson 1999). Early years practitioners report spending significantly more time on literacy activities (21% of the school day), compared to mathematics (5-8% of the school day; Early et al. 2005; Siraj-Blatchford et al. 2002), thus demonstrating a "maths-practice" gap (Stacy et al. 2017). Evidence also suggests preschool mathematics instruction is often

sparse and not aligned with children's current level of mathematical development (Litkowski et al. 2020). For example, mathematics activities that are implemented in preschool typically focus on counting and cardinality (Von Spreckelsen et al. 2019), compared to more advanced aspects of mathematical development, such as sequences and place value, which are much less frequent (Klibanoff et al. 2006). This may reflect myths surrounding early mathematics that instruction focused on basic skills, such as simple numbers, is sufficient, and that young children are not ready for mathematics education (Clements and Samara 2018).

Current Study

To date, most research examining early years practitioners' perceptions, classroom practices, and beliefs of early mathematics has been conducted in the US (Linder and Simpson 2018). Similar research is needed to support effective educational policy and practice in the UK, where 20% of young children do not achieve the expected attainment for mathematics (DfE 2017b).

In the UK, standards in child learning, development, and care from birth to 5 years is guided by the Early Years Foundation Stage (EYFS) framework (DfE 2017a). The EYFS framework includes developmental milestones and learning outcome goals across general (e.g. personal, social, and emotional development) and specific subject domains (e.g. literacy and mathematics). For literacy, children need to begin to read and write, including learning to correspond sounds (phonemes) to written letters (graphemes). For mathematics, children need to start counting, understanding and using numbers, calculating simple addition and subtraction problems, as well as describing shape, space and measures. The framework also guides the necessary qualifications, training, support, and skills of early years practitioners. It is statutory for all early years providers in England, however Scotland and Wales also implement similar guidelines (DfE 2017a).

The data in this survey was collected in 2016, after a policy was introduced which expected all early years staff to have a minimum grade C GCSE level or equivalent for both English as well as maths (DfE 2014). Thus, it could be predicted that practitioners should have equal confidence and knowledge related to providing mathematical, as well as literacy activities. For the first time, this study examined early years practitioners' perceptions, classroom practices, and beliefs of early mathematics, relative to literacy and life skills, within a UK-based setting. This study also extended on previous research by considering associations between these factors. Specifically, this study asked three research questions.

This study asked, 1) how do early years providers' self-reported perceived importance of mathematics, compare to literacy and life skills (e.g. eat using a fork, See Supplementary Materials)? Followed by, 2) how often do preschool providers report implementing formal and informal mathematics activities, compared to formal and informal literacy in their classroom? Although all skill areas are well represented in the statutory guidelines for early years in the UK (DfE 2017a), it was hypothesized that early years practitioners would rate life skills and literacy as more important than mathematics and that implementation of literacy activities would be reported more frequently than mathematics activities in the classroom. These predictions were based on previous studies in this area (e.g. Simpson and Linder 2014; Stacy et al. 2017). Finally, this study asked, 3) does early years practitioners' self-reported confidence in and beliefs towards mathematics influence their perceived importance and frequency of mathematical activities in their classroom practices? Based on previous research (e.g. Anders and Rossbach 2015; Copley 2004; Pajares 1992), it was predicted that practitioners with less confidence in mathematics would report providing fewer mathematical activities in the classroom and those with more positive general beliefs towards mathematics would also place a greater value on the importance of mathematics in the early years. These research questions were based on the continued professional development (CPD) model by Rouse (2008), with three aspects of development: knowing, doing, and believing. According to Rouse's model, any two elements influence the third element. By taking such an approach, it will provide insights into some of

the factors that drive early years teachers' classroom practices and highlight avenues for CPD in this area and provide insight into how future CPD can be improved.

Methods

Design and Participants

This study conducted an online survey with early years practitioners in the UK assessing their self-reported perceptions, classroom practices, and beliefs of early mathematics relative to other early years skills, including literacy and life skills. Participants were recruited via opportunity sampling within the authors' professional networks from various early years settings in Greater London in the UK in 2016. A total of 83 early years practitioners, 91% female, from 11 early years setting completed the survey. The sample consisted of a range of job roles, including early years practitioner (36.1%), nursery nurse[1] or assistant (34.9%), centre manager (8.4%), and room leader (7.2%). 13.3% of respondents did not indicate their job role. However, all were involved in children's daily activities and teaching practices. Participants ranged in years of teaching experience, including less than 1 year (4.8%), 1-3 years (10.8%), 3 to 10 years (21.6%), and more than 10 years (36.0%). 26.5% of respondents did not indicate their years of teaching experience. 79.5% of early years practitioners had the government recommended minimum Level 3 diploma early years qualification, including 31.3% of participants with a University degree (Bachelors or higher). 13.3% of participants did not yet meet the government recommended educational level requirements for early years practitioners but were training towards them and 7.2% participants did not indicate their educational level. The proportion of participants with at least a level 3 diploma early years qualification in this sample was aligned with the national population (DfE 2017c). Ethical approval for this study was obtained from the XXXXXX ethics committee and teachers provided their explicit consent to take part in the study which was entirely anonymous.

[1] Early years practitioners are also known as nursery nurses. They are specialists who look after the social and educational development of babies and young children up to the age of five years old.

Materials

Early years practitioners completed a questionnaire designed specifically for this study. The questionnaire items were selected by drawing on research evidence about mathematical and literacy development in the preschool and home learning environment (e.g. Kleemans et al. 2012; LeFevre et al. 2009; Skwarchuk 2009). The questionnaire focused on three areas: early years practitioners' perceived importance of life skills, literacy, and mathematics (Topic A), the frequency in which they implement literacy and mathematics classroom activities (Topic B), and their confidence and beliefs towards mathematics (Topic C). All questionnaire items are included in the Appendix. Early years practitioners also provided demographic information relating to their job role, years of teaching experience, and relevant qualifications and educational level. Participants were not aware of the researchers' focus on mathematics.

Topic A: Perceived importance of life skills, literacy, and mathematics.

Early years practitioners rated their perceived importance of achieving end-of-year benchmarks in 17 specific skills on a 5-point Likert scale from 1 (not important) to 5 (extremely important). Five items referred to life skills (e.g. eat using a fork), four items referred to literacy skills (e.g. write letters of the alphabet) and eight items referred to mathematical skills (e.g. count to 10). An additional two items (see Appendix) were included as control, distractor items and were not considered in later analyses. Overall life skills, literacy, and mathematics subject domain scores were calculated by mean averaging item rating responses within each subject. Reliability analysis for each subject domain showed high internal consistency, Cronbach's α = .87-.93 (see Table 1).

Topic B: Frequency of literacy and mathematics classroom activities.

Next, early years practitioners rated the frequency in which they implement 30 literacy and mathematics activities in their classroom on a 5-point Likert scale from 1 (do not engage at all) to 5 (engage several times per day). Four items referred to formal literacy activities (e.g. practice reading words), three items referred to informal literacy practices (e.g. playing game involving letters), nine items referred to formal mathematics activities (e.g. recite numbers in order), and fourteen items

referred to informal mathematics practices (e.g. play dominoes). An additional two items (see Appendix) were included as control, distractor items and were not considered in later analyses. Overall formal and informal literacy and mathematics scores were calculated by mean averaging item rating responses within each area. Reliability analysis for each area showed medium- high internal consistency, Cronbach's α = .58- .90 (see Table 1).

Topic C: Confidence and beliefs towards mathematics.

Finally, early years practitioners rated their confidence in and general beliefs towards mathematics across nine items on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Four items referred to confidence in mathematics (e.g. I feel comfortable solving mathematics problems) and five items referred to general beliefs towards mathematics (e.g. maths is a worthwhile and necessary subject). An additional six items on the same 5-point Likert scale asked early years practitioners about their views towards preschool mathematics (four items) and literacy (two items) and were analysed descriptively (see Appendix). A further four items (see Appendix) were included as control, distractor items and were not considered in later analyses. Overall confidence and belief scores were calculated by mean averaging item rating responses within each area and reliability analysis showed medium- high internal consistency, Cronbach's α = .62- .86 (see Table 1).

Table 1 about here

Handling missing data

Missing data is very common in survey research (Brick and Kalton 1996). In cases of item nonresponse (e.g. a respondent accidently missed one questionnaire item within a topic) single imputation with expectation maximisation was used to predict and replace the missing data (Heymans and Eekhout 2019). Single imputation procedures were applied at the level of the subject domain/area (e.g. life skills, literacy, and mathematics) within each topic of the questionnaire (e.g. Topic A: Perceived Importance). When questionnaire topics were fully incomplete, these participants were excluded from later analyses. Table 1 includes the final sample *n* for each questionnaire topic.

Results

Although specific predictions were made (see Section 1.4.), all results are reported at two-tailed level of significance to ensure findings would be more robust. Table 1 reports early years practitioners' mean responses for each questionnaire topic. Shapiro-Wilk tests showed all variables were normally distributed (p >.05), except practitioner beliefs towards to mathematics, which was shown to significantly deviate from normality, W (77) = .93, p < .001.

Perceived Importance of Life Skills, Literacy, and Mathematics

When comparing early years practitioners' perceived importance of mathematics relative to literacy and life skills, a one-way ANOVA revealed mean importance ratings (see Table 1) significantly differed across the three subject domains, $F(2,162) = 48.18$, $p < .001$, $\eta_p^2 = .37$. Post-hoc Bonferroni corrected pairwise comparisons showed, successfully acquiring life skills was rated more important than mathematical (M = .62, p < .001, Cohen's d = 1.08) or literacy skills (M = .44, p < .001, Cohen's d = .62). Preschool literacy skills were also rated more important than mathematics (M = .18, p = .011, Cohen's d = .36). As can be seen in Figure 1, even though there was great variability for each of the items, items related to life skills and literacy skills scored higher.

Figure 1 about here

Frequency of Daily Literacy and Mathematics Classroom Activities

To examine how often early years practitioners implement formal and informal mathematics activities, compared to formal and informal literacy in their classroom, mean reported frequencies (see Table 1) were compared using a two-way ANOVA with subject domain (literacy, mathematics) and type of activity (formal, informal) as factors. Results showed significant main effects of subject domain, $F(1,77) = 34.27$, $p < .001$, $\eta_p^2 = .31$, and type of activity, $F(1,77) = 15.50$, $p < .001$, $\eta_p^2 = .17$, as well as a significant interaction between the two factors, $F(1,77) = 25.99$, $p < .001$, $\eta_p^2 = .25$.

Planned comparisons were conducted within and across each subject domain and type of activity with a Bonferroni corrected alpha level ($\alpha = .05/4 = .0125$). Results showed informal literacy activities were significantly more common than informal mathematics activities, $t(77) = 7.85$, p < .001, Cohen's d = .93. There was no significant difference in frequencies of formal literacy and

formal mathematics activities, $t(77) = 1.20$, $p = .235$, Cohen's $d = .16$. There was also no significant difference in reported frequency of formal and informal literacy activities, $t(77) = .16$, $p = .876$, Cohen's $d = .02$. However, formal mathematics activities were significantly more frequent than informal mathematics, $t(77) = 7.80$, $p < .001$, Cohen's $d = .88$. Pearson's correlation showed a significant, positive association between overall reported frequency of daily mathematics activities (formal and informal) and perceived importance of mathematics in the early years ($r = .56$, $p < .001$, see Table 2). Responses to individual items can be found in Figure 2.

Figure 2 about here

Confidence and Beliefs Towards Mathematics

Finally, to examine the associations between early years practitioners' mean reported confidence in and general beliefs towards mathematics (see Table 1), and the relationships with classroom practices a Pearson's correlation matrix[2] with a Bonferroni corrected alpha levels ($\alpha = .05/2 = .025$) was conducted (see Table 2). Results showed early years practitioners' confidence in their own mathematical abilities and their general beliefs towards mathematics were significantly and positively associated. Furthermore, they were associated with the overall reported frequency of mathematical activities (formal and informal) implemented in their classroom and their perceived importance of mathematics in the early years, respectively.

Table 2 about here

Discussion

Preschool foundations have a lasting impact on children's later educational successes (Anders et al. 2012; Sylva et al. 2010). As such, early learning experiences that support mathematical development are vital to children's long-term outcomes (Clements and Sarama 2009; Duncan et al. 2007). The current study examined UK-based early years practitioners' perceptions, classroom practices, and beliefs towards early mathematics back in 2016 before the latest reforms took place.

[2] Despite practitioner beliefs towards mathematics shown to deviate significantly from normality, more conservative non-parametric Spearman's Rho correlations showed the same pattern of results.

Specifically, the current study aimed to obtain a better understanding of how mathematics is viewed and implemented in preschool learning environments, as well as how it compares to other subject areas of the EYFS framework (DfE 2017a), including literacy and life skills. According to Rouse's CPD model (2008), educator practice evolves around their knowledge, beliefs, and actions, with any two elements influencing the third element. However, as discussed by Ernest (1989), teachers beliefs impact on their practice and their willingness to change. In addition, if their beliefs are not in line with the proposed curriculum teachers' practice often differs from the intended curriculum (Handal & Herringdon, 2003). As such, a better understanding of teacher knowledge, beliefs and actions allows better insight into how early years practitioner practice could be improved and what future CPD courses should focus on.

When comparing the perceived importance of life skills, literacy, and mathematics, 92.6% of early years practitioners surveyed agreed or strongly agreed that it is important for preschoolers to develop their mathematical skills. Yet, the perceived importance of young children achieving specific mathematical milestones before starting formal education was rated significantly lower compared to milestones in literacy and life skills. This evidence was in line with hypotheses and corroborates previous studies in the USA (Ginsburg, Lee, and Boyd 2008) and Europe (Artemenko et al. 2021), which demonstrate similar findings, where the importance of early mathematics is acknowledged but is considered less important relative to other key skills in preschool (Simpson and Linder 2014; von Spreckelsen et al. 2019).

In examining the frequency of literacy and mathematics activities implemented in daily classroom practice, over 92% of early years practitioners surveyed agreed or strongly agreed that it is important for children to be exposed to mathematical concepts (92.5%) and reading (95.1%) every day. However, consistent with predictions, practitioners also reported implementing significantly more literacy activities in the daily classroom routine compared to those with a focus on mathematical abilities. Furthermore, while 93.9% of practitioners agreed or strongly agreed that young children learn mathematical skills best through play, comparisons of type of activities implemented (formal, informal) showed formal mathematics activities (e.g. recite numbers in order) were implemented

significantly more frequently within daily classroom practice than informal mathematics activities (e.g. play dominoes).

This finding might be counter-intuitive, as we are surrounded by maths and numbers and thus, it should be easy to implement informal maths activities throughout the day. One possibility is that the early years practitioners are not clear how mathematical abilities develop in young children and thus are not clear what might count as an informal mathematical activity. However, the current survey did not ask the participants about what they thought were informal activities but to list how often they did these particular tasks. So, it is more likely that they do not include informal activities, such as connect-the-dots, colouring by numbers, or playing board games with dice, as they might not value how these activities can improve children's mathematical abilities. This is an important finding as it shows future CPD should focus on providing early years practitioners with an understanding of why informal maths activities can benefit young children's mathematical development.

Indeed, this is corroborated by the finding that the reported frequency of daily mathematics activities was significantly correlated with perceived importance of young children developing key mathematical skills by the end of preschool (from Topic A). These results are consistent with the "maths-practice gap" (Stacy et al. 2017) and agree with other survey research demonstrating significantly more time devoted to developing literacy skills compared to mathematics both in the preschool (Early et al. 2005) and home learning environment (Cannon and Ginsburg 2008).

Finally, when examining early years practitioners' confidence and beliefs towards mathematics, 85.2% of respondents agreed or strongly agreed that they find reading enjoyable, compared to 65.8% for mathematics and 70.9% for maths-based activities. This observed preference for literacy over mathematics, is consistent with previous research (Copley 2004), despite the fact that most practitioners in the current study met the minimum requirements for Maths and English. This shows that just raising the required maths and English knowledge and skills for early years practitioners is not sufficient to raise practitioners' confidence to deliver the activities. In extending on previous research, the current study found, in line with predictions, that the frequency with which early years practitioners implemented mathematical activities in their classroom was significantly and

positively associated with reported confidence in their own mathematical abilities (e.g. I feel comfortable solving mathematics problems). Likewise, their perceived importance of young children achieving key mathematical skills at the end of preschool was significantly and positively associated with their general beliefs towards mathematics (e.g. maths is a worthwhile and necessary subject).

Implications for Education Policy and Practice

Best practice and conducive beliefs are shaped through experience and formal training (McMullen 1997). Although our sample is relatively small, the current findings suggest more effective teacher training in mathematics is required in early years settings. In many countries, including the UK, early years practitioners do not receive extensive initial or continued training in mathematics (Gifford, 2010). Recent recommendations for CPD relating to improving mathematics in the early years emphasised the need to enrich practitioners' knowledge of mathematical development and how this translates to effective mathematical pedagogies (EEF, 2020).

In particular, mathematical development is multi-componential in nature (Gilmore and Cragg, 2014) and is sometimes argued to be more complex in comparison to literacy development (Stacy et al., 2017). For example, mathematics is an umbrella term that covers a wide range of abilities, even at preschool age, including knowledge of number names, digit recognition, knowledge of operations, applying the precise counting sequence, understanding what counting is for, understanding of set similarities and differences, relationship between numbers, and recognising simple shapes and patterns (EEF, 2020). Early years practitioners need to have a solid understanding of the complexity of mathematics, how these different mathematical concepts are related, and how these interconnected skills can be taught with both formal and informal learning activities in ways that effectively build on children's prior knowledge.

Furthermore, the current findings are indicative for the need for CPD to consider practitioner values and confidence. As practitioner beliefs may influence how a curriculum or intervention is implemented (Rogers 2003), it is vital to raise awareness of the importance of early mathematical development and its influence on later educational outcomes (e.g., Duncan et al., 2007). Not only do

practitioners need a minimum level of education in terms of subject knowledge, but they also need to feel confident and well-equipped to be able to effectively implement the recommended mathematical activities. Previous intervention studies that have included these components have shown positive impacts in reducing practitioners' anxieties towards teaching mathematics (Gresham, 2007).

The need to enrich early years practitioners' expertise and confidence in early mathematical development is particularly relevant and timely to recent changes to the EYFS framework the UK (DfE 2019). As part of these changes, the content of the EYFS framework has an increased focus on number and numerical patterns, with numerical patterns replacing shape, space, and measure end-of-year benchmarks. While the changes may positively enhance children's early mathematical development, given the strong predictive role of early number skills on later mathematical achievement (e.g. Merkley and Ansari 2016), practitioners must receive effective continued professional development in order to feel confident and well-equipped to deliver this new curriculum.

Limitations and Future Directions

The current study expands our understandings of early years practitioners' perceptions, classroom practices, and beliefs of early mathematics in UK-based early years settings. It draws on a limited opportunity sample of 83 early years practitioners with a range of job roles, years of teaching experience, and relevant qualifications, and educational levels. As such, further research examining how representative the findings from the current study are for the entire preschool workforce, by looking at sub-groups for example (see Artemenko et al., 2021 in Europe), is required. In addition, the data was mainly obtained in 2016 and thus, it is important to examine whether these findings still hold. Seeing the current findings relied on self-report, future research may also benefit from observational findings of practitioners' actual practice. In guiding future research, it will be beneficial to consider how the currently investigated factors may also impact on children's early learning outcomes. Furthermore, other factors underpinning children's early mathematical abilities, including language, spatial and executive function skills (Hawes et al. 2019; Purpura, Napoli, and King 2019) should also be examined. Connecting these different factors across the different levels of the preschool learning environment (Bronfenbrenner 1979; Outhwaite, Gulliford, and Pitchford 2019)

will help target effective instructional practices to children who may be vulnerable to mathematical difficulties.

Conclusion

In sum, this study emphasises a 'maths-practice gap' (Stacy et al. 2017) as early years practitioners reported implementing activities focused on literacy in their daily classroom routine significantly more frequently than mathematics. By examining the different types of maths activities, the current findings demonstrate that activities focused on mathematical content were typically formal, despite practitioners acknowledging that children learn mathematics best through play. Reported for the first time, early years practitioners' confidence and beliefs towards mathematics were associated with reported overall frequency of and perceived importance of mathematics in the early years, respectively. Overall, this evidence highlights avenues for improving CPD for early years practitioners that enriches awareness, knowledge, and confidence surrounding early mathematical development. Importantly, these avenues go beyond current UK government policy requirements for early years practitioners to have a minimum school-leaving-age qualification in mathematics (DfE, 2014). This is also particularly vital in the UK with current changes to the EYFS framework, which may place increased demands on and challenges for early years practitioners.

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Table 1

Descriptive statistics for each subject domain/area per topic of the preschool teacher questionnaire.

Questionnaire Items	*n*	Cronbach's α	Mean (SD)	Min-Max
Topic A: Perceived importance				
Life skills	82	.81	3.52 (.83)	1.60 – 5.00
Literacy	82	.90	3.09 (1.00)	1.00 – 5.00
Mathematics	82	.93	2.90 (.93)	1.13 – 5.00
Topic B: Frequency of daily literacy and mathematics classroom activities				
Formal literacy	78	.71	3.23 (.87)	1.00 – 5.00
Informal literacy	78	.58	3.22 (.73)	1.00 – 5.00
Formal mathematics	78	.85	3.16 (.69)	1.00 – 4.56
Informal mathematics	78	.90	2.76 (.70)	1.00 – 4.50
Overall mathematics	78	.93	2.91 (.66)	1.00 – 4.48
Topic C: Confidence and beliefs towards mathematics				
Confidence in mathematics	82	.86	3.40 (.88)	1.00 – 5.00
Beliefs towards mathematics	82	.62	4.41 (.47)	3.00 – 5.00

Table 2

Correlation matrix between practitioner confidence and beliefs towards mathematics and classroom practices.

Assessment	Correlation *r* (r^2)			
	1	**2**	**3**	**4**
1. Confidence in mathematics	-			
2. Beliefs towards mathematics	.33** (.11)	-		
3. Overall frequency of mathematics	.31** (.10)	.23 (.05)	-	
4. Perceived importance of mathematics	.25* (.06)	.27* (.07)	.56** (.31)	-

**$p < .01$; *$p < .025$

Figure 1. Scores for each item related to life skills, literacy and mathematics

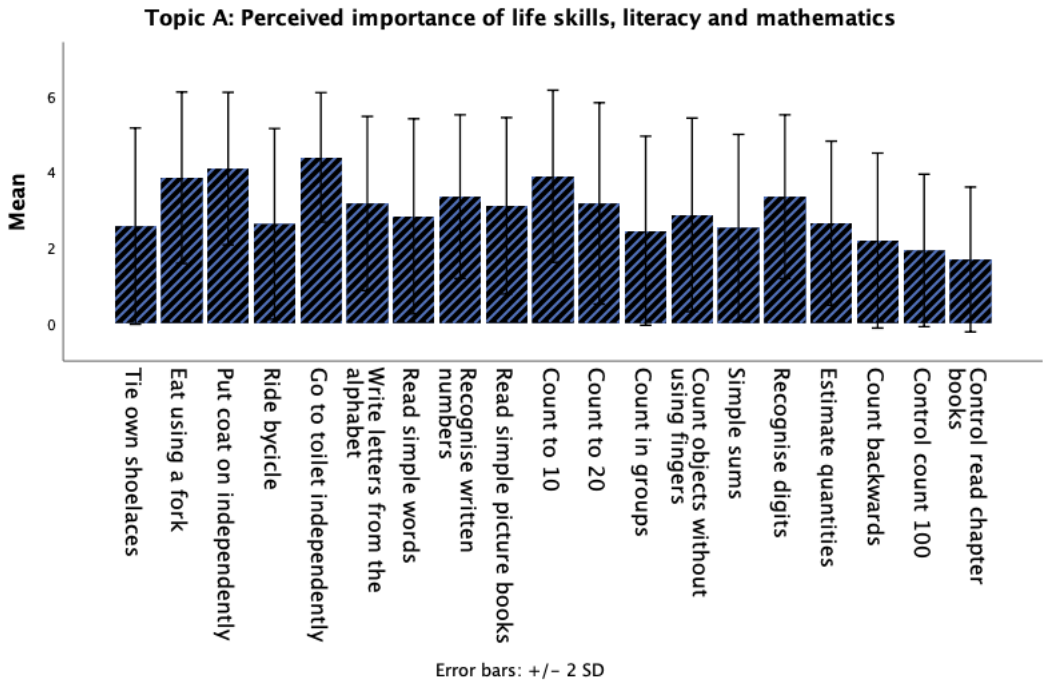
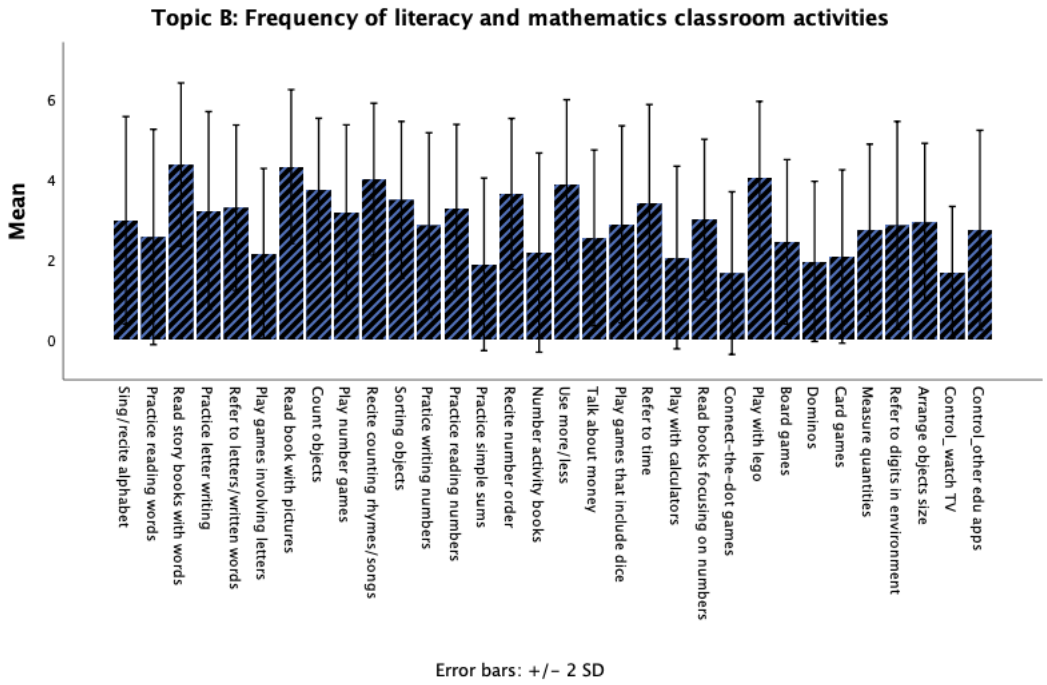


Figure 2. Frequency of formal and informal literacy and mathematic classroom activities



Appendix

Preschool teacher questionnaire items for each subject domain/area per topic

Topic A: Perceived importance of life skills, literacy and mathematics	
Life skills 1	Tie their own shoelaces
Life skills 2	Eat using a fork
Life skills 3	Put coat on independently
Life skills 4	Ride a bicycle
Life skills 5	Go to the toilet independently
Literacy 1	Write letters of the alphabet
Literacy 2	Read a few words
Literacy 3	Identify/ recognize written numbers
Literacy 4	Read simple picture books
Mathematics 1	Count to 10
Mathematics 2	Count to 20
Mathematics 3	Count in groups of 2, 5, or 10
Mathematics 4	Count objects to 20 without using fingers
Mathematics 5	Know simple sums (e.g. 2 + 2, 2 – 1)
Mathematics 5	Identify/ recognise digits
Mathematics 6	Estimate quantities (e.g. guess how many sweets in the jar)
Mathematics 7	Count backwards from 20
Control 1	Count to 100
Control 2	Read chapter books

Topic B: Frequency of literacy and mathematics classroom activities	
Formal literacy 1	Sing/ recite the alphabet
Formal literacy 2	Practice reading words
Formal literacy 3	Read or look at story books (with words)
Formal literacy 4	Practice writing letters or words
Informal literacy 1	Refer to letters or written words in the environment (e.g. identify words on signs)
Informal literacy 2	Play games involving letters (e.g. lotto, boggle, scrabble)
Informal literacy 3	Read or look at picture books
Formal mathematics 1	Count objects (e.g. you ask how many are there?)
Formal mathematics 2	Play arithmetic games that involve counting, adding or subtracting (e.g. on the computer, iPad, or on paper)
Formal mathematics 3	Recite counting rhymes or songs (e.g. 5 little monkeys)
Formal mathematics 4	Sort objects by colour, size, or shape
Formal mathematics 5	Practice writing numbers
Formal mathematics 6	Practice reading numbers (e.g. being able to recognize “1” and say it’s name “one”)
Formal mathematics 7	Practice simple sums (e.g. 2 + 2 = 4)
Formal mathematics 8	Recite numbers in order (e.g. count up to or back from 10)
Formal mathematics 9	Number activity books
Informal mathematics 1	Use concepts such as more/less, full/half- full, short/long
Informal mathematics 2	Talk about money when shopping (e.g. which one costs more?)
Informal mathematics 3	Play games involving numbers (e.g. snakes and ladders)
Informal mathematics 4	Refer to time (e.g. talk about the time; child wears a watch; use calendars and dates)
Informal mathematics 5	Play with calculators
Informal mathematics 6	Read storybooks specifically focused on numbers

Informal mathematics 7	Connect-the-dot or colour-by-number activities
Informal mathematics 8	Build lego or construction sets
Informal mathematics 9	Play board games with die or spinner
Informal mathematics 10	Play dominoes
Informal mathematics 11	Play card games
Informal mathematics 12	Weigh, measure, and/or compare quantities (e.g. measure ingredients when cooking)
Informal mathematics 13	Refer to digits (“6”) or written numbers (“six”) in the environments (e.g. the number on the bus)
Informal mathematics 14	Arrange objects (e.g. from big to small)
Control 1	Watch educational TV shows
Control 2	Use educational software or apps, focused on something other than numbers

Topic C: Confidence and beliefs towards mathematics	
Confidence maths 1	I am confident in my mathematics abilities
Confidence maths 2	I am good at mental calculations
Confidence maths 3	I feel comfortable solving mathematical problems
Confidence maths 4	I find mathematics activities enjoyable
Beliefs maths 1	Maths is a worthwhile and necessary subject
Beliefs maths 2	A strong mathematical background helps in adult life
Beliefs maths 3	Mathematical skills help with problem-solving in other areas of life
Beliefs maths 4	Mathematical skills are useful in all areas of life
Beliefs maths 5	Maths is one of the most important subjects
Topic C: Descriptive items	
Descriptive mathematics 1	Young children learn mathematical skills best through play
Descriptive mathematics 2	It is important for preschoolers to develop their mathematical skills
Descriptive mathematics 3	It is important for children to be exposed to mathematical concepts every day
Descriptive mathematics 4	I enjoy delivering maths-based activities in the nursery
Descriptive literacy 1	I find reading enjoyable
Descriptive literacy 2	It is important for children to be exposed to reading every day
Control 1	I try to incorporate mathematical learning into daily life in the nursery wherever I can
Control 2	When I was at school, I was good at language/arts activities, such as reading or art.
Control 3	When I was at school, I was good at Mathematics.
Control 4	When I was at school, I enjoyed mathematics.