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Is Confidence in Mathematics Pedagogy Enough? Exploring Early Childhood Teachers' Mathematics Beliefs and Confidence

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Abstract

A multicentre cross-sectional study of early childhood teachers (ECTs) from one large Australian not-for-profit early childhood organisation in preschool (3–5 years) classrooms, was conducted. This study was part of a quasi-experimental online Mathematics Professional Learning Program intervention aimed at developing ECTs' mathematical pedagogical content knowledge; we report on ECTs' (n = 325) pre-program survey scores, investigating their beliefs and confidence around mathematical pedagogy and their beliefs of preschoolers' mathematical abilities. Scores were high, especially for confidence in pedagogical knowledge and pedagogical ability in helping children learn mathematics, and several survey constructs were significantly inter-related. However, more than half of the ECTs did not agree that most children enter preschool with some mathematics abilities, and confidence in their own mathematical abilities in areas of numeracy and spatial awareness varied. Mathematics focussed Environmental Rating Scale, Early Childhood Environment Rating Scale—Extension (ECERS-E) and Sustained Shared Thinking and Emotional Wellbeing (SSTEW) scale, item scores were evaluated for a representative subgroup of ECTs (n = 102) and overall showed *minimal* (3 out of 7) quality learning environments. Mathematical beliefs and confidence had a weak association with mathematics focused ECERS-E scores and no association with SSTEW scores. The results show that while beliefs and confidence were high, they did not predict the quality of the preschool learning environment. ECTs may be unaware of the specific mathematical content knowledge and pedagogical content knowledge required to effectively teach mathematics to preschool children and develop children's complex mathematical thinking. Implications for professional learning are discussed.

Keywords Early childhood mathematics · Professional learning · Environmental rating scale · Mathematics teaching efficacy

Introduction

Early Childhood Mathematics Teaching and Learning

Recent early childhood educational and cognitive neuroscientific research indicate that early years' learners are capable of complex mathematical thinking and use it to make sense of their world (Clements & Sarama, 2020; Papic et al., 2023) with the foundations of mathematical thinking and learning occurring in the early childhood years (Papic, et al., 2013). These are foundations for more abstract mathematics children learn at school and contribute significantly to their achievement in both mathematics and educational success more broadly in later schooling (Anders & Rossbach, 2015; Duncan et al., 2007).

Play-based learning predominates in many western contexts with child-centred social pedagogy based on interests, embedded in play and everyday experience, being the dominant pedagogical approach (Anders & Rossbach, 2015; Barenthien et al., 2020; Stephenson et al., 2023). However, research (e.g., Dockett et al., 2014; Papic et al., 2011) has highlighted the importance of intentionality in the mathematics classroom where educators and teachers support children's learning through worthwhile, challenging, and

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purposeful experiences and interactions that foster high-level thinking and reasoning skills. "Play-based learning with intentionality can expand children's thinking and enhance their desire to know and to learn, promoting positive dispositions towards learning" (Australian Government Department of Education [AGDE], 2022, p. 21). Abstract and complex mathematical learning requires teachers to be intentional, with explicit attention to mathematical concepts, processes and ideas and a commitment to authentic, mathematical learning opportunities and interactions (Papic & Carmichael, 2013). Teacher knowledge of mathematics is viewed as a key contributor to effective teaching and consequentially, student learning, in the early childhood years (Bobis et al., 2005; Papic et al., 2009).

Mathematical Professional Knowledge

Quality early childhood education requires teachers to have professional knowledge (Lee, 2010). Professional knowledge includes content knowledge (CK) and pedagogical content knowledge (PCK) (Lee, 2010; McCray & Chen, 2012). Mathematical content knowledge is the essential subject matter knowledge required for teaching mathematics (Shulman, 1987). Pedagogical content knowledge is knowledge "which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" and includes "the ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986, p. 9). According to Gasteiger et al. (2020), mathematical PCK for early childhood teachers (ECTs) can be defined as "knowledge about ways to create and modify mathematical learning environments for young children, knowledge about ways to analyse mathematical development, and knowledge about ways to give, sometimes spontaneously, adaptive support in natural learning settings" (Gasteiger et al., 2020, p. 195).

Early childhood teachers require an understanding of the big ideas of mathematics and the relevant concepts and, of effective pedagogy that supports diverse learners' development of these concepts (McCray & Chen, 2012; Sylva et al., 2013). While we know ECTs need well developed CK and PCK as well as diagnostic knowledge and skills (Ball et al., 2008) to meet these demands for example, to identify counting principles and address misconceptions in counting, or model appropriate problem-solving strategies, there is a paucity of studies that have empirically investigated ECTs' levels of PCK and how it relates to the quality of the learning environment and to teaching (Anders & Rossbach, 2015).

Environmental Rating Scales to Assess Quality

Early childhood teachers' mathematical CK and PCK affect the quality of teaching and learning in the classroom (McCray & Chen, 2012). But how is quality defined and how can it be measured? Sylva et al., (2004) define quality in early childhood education settings as those that support and enhance children's outcomes. Quality rating scales have been used widely in studies to measure quality, and the changes in quality over time (e.g., Siraj et al., 2018). Two such scales are the Sustained Shared Thinking and Emotional Wellbeing (SSTEW) scale and the Early Childhood Environment Rating Scale—Extension (ECERS-E) (Siraj et al., 2015; Sylva et al., 2003). Both scales support, increase, and improve the identification and practice of high-quality interactions within early childhood education and care settings (Siraj et al., 2018). ECERS-E identifies aspects of curricular quality, such as mathematical, scientific and literacy learning, and diversity (Siraj et al., 2018) providing a fine-grained analysis of curriculum provisions in those learning areas found to contribute to positive learning and development outcomes in the longer term for children. ECERS-E can support analysis of specific teaching imbalances in a setting, where some aspects of teaching may be good/adequate, but others are underdeveloped (Lundqvist et al., 2023; von Spreckelsen et al., 2019). SSTEW highlights practices that help children aged 2–5 years develop skills in sustained shared thinking, emotional well-being, building strong relationships, effective communication, and aspects of self-regulation (Howard et al., 2018). SSTEW acknowledges the significance of child-centred, developmentally appropriate practices that promote continuous learning, helping children become self-regulated and autonomous learners (Howard et al., 2018).

Environmental Rating Scales are widely used internationally both in research and in practice. In a systematic examination of early education and care quality in 23 countries across five geographic regions, Vermeer et al., (2016) found higher quality levels in both Australia/New Zealand and North America, as measured by Environment Rating Scales (ERS), with ERS scores rarely falling below 3 (Harrison, 2010). In relation to numeracy, an Australian study (Howard et al., 2018) of 45 preschool centres and 669 preschool children, showed both ECERS-E and SSTEW consistently predicted early numeracy development, which aligns with the findings of the UK longitudinal study: The effective provision of preschool education project (EPPE), study (Siraj-Blatchford et al., 2008). The results of the EPPE study emphasized that the quality of early childhood education and care has a stronger impact on numeracy outcomes than on language or social-behavioural outcomes (Sammons et al., 2002, 2003).

Beliefs and Confidence of Early Childhood Teachers Around Mathematics Pedagogy

ECTs' pedagogical beliefs—their ideas about appropriate educational goals and practices, the role of the teacher, the purpose of early childhood education "influence pedagogical interactions and their process quality, and thus also may affect children's learning processes" (Anders & Rossbach, 2015, p. 309). Teacher beliefs comprise conceptualisations of practice in relation to student learning (Ring et al., 2017). While teachers must implement curriculum endorsed by national and state education departments, their beliefs can result in the success or failure of new educational approaches (Jamil et al., 2018). Beliefs are the "best indicators of the decisions individuals make" (Pajares, 1992, p. 307) and are a "major determinant of behaviour" (Vartuli, 2005, p. 76).

Teacher beliefs and confidence around the subject of mathematics affect their thinking, motivation, and behaviour as well as their approach to teaching (Chen & McCray, 2013). However, recent research (e.g., Geist, 2015; Perry & MacDonald, 2019; Stephenson et al., 2023) suggests that ECTs have low confidence and capacity to teach mathematics. There can be several competing concerns that affect ECT's beliefs and confidence about mathematics: personally held perceptions of teachers' own mathematical ability and mathematics teaching efficacy, beliefs about what is appropriate for young children to learn and beliefs about what young children are capable of learning—negative beliefs about any of these can lead to a lack of motivation to provide children with mathematical learning.

Chen et al. (2014) in their study with 346 ECTs, investigated a range of ECT beliefs about mathematics in the development of the *Early Math Beliefs and Confidence Survey* (EM-BCS). To understand the scope of ECT's beliefs about mathematics, Chen and colleagues developed 28 very specific first-person statements to determine participant beliefs about *what preschoolers can learn*, beliefs about *what preschoolers need to learn* and beliefs about *how effective the teacher can be* to support this learning. This final category of question was refined to specifically investigate teachers' beliefs of their *personal mathematical ability* as well as their self-perceived mathematical teaching ability. The findings of the study run somewhat counter to past findings about ECT's confidence and beliefs about their capacity to teach mathematics. Overall, the study highlighted a positive view of mathematics' relevance to preschoolers and confidence in teaching preschool mathematics, although this was not a uniform picture for all aspects of the study.

Mathematics Anxiety

Personal perceptions of mathematics ability and knowledge are powerful. Negative personal feelings about mathematics ability and efficacy can manifest itself in mathematics anxiety (MA), with feelings of fear and shame about mathematics, leading to avoidance of mathematics related activities, which may include mathematics teaching (Gresham & Burleigh, 2019). These feelings can arise quite early in individual's lives and persist into adulthood.

The perception of early childhood education as an area of teaching with a low mathematics requirement was suggested by recent German research (Jenßen, 2021): 774 general vocational education students (who could choose to work in early childhood education amongst other career paths) were assessed for MA and asked if they were planning to work in early childhood. Those students who had MA were more likely to choose early childhood. The relationship between MA or low mathematical self-efficacy and *mathematics teaching anxiety* is not predictable however (Gresham & Burleigh, 2019), initial teacher education and subsequent professional development can support increased confidence, content knowledge and pedagogical knowledge (Barenthien et al., 2020; Gresham & Burleigh, 2019).

Objectives of the Study

A study with Australian ECTs from a large not-for-profit (NFP) Australian Early Childhood Provider evaluated the effectiveness of a 12-month *online Mathematics Professional Learning Program (MPLP)* focused on developing ECTs' mathematical content and pedagogical content knowledge on:

- Improving the quality of the learning environment.
- Provisioning the classroom environment to provide opportunities for mathematical investigation and learning.
- Efficacy in supporting children's mathematical development and higher order thinking skills.
- ECTs' confidence and beliefs toward mathematics and mathematics teaching.

This paper reports on baseline data collected prior to the commencement of the MPLP where we evaluated i) ECTs' confidence and beliefs towards teaching early mathematics; ii) the inter-relationships between ECTs' beliefs of their mathematical content and pedagogical knowledge, and their beliefs of preschoolers' mathematical abilities; iii) the relationship between ECTs' mathematics beliefs and confidence and mathematics focussed ERS scores (ECERS-E and SSTEW). The findings from the baseline data add to the research literature on ECTs' beliefs and confidence around the subject of mathematics and how this affects their thinking and approach to the teaching and learning of this area of the curriculum (e.g., Chen & McCray, 2013). The findings also add to the literature on the use of Environment Rating Scales ECERS-E and SSTEW in the Australian context (e.g., Howard et al., 2018), providing new insights into the association between ECTs' early mathematics beliefs and confidence and ERS scores.

Methods

A multicentre cross-sectional study of ECTs from one large Australian NFP early childhood organisation was conducted. Participants completed a validated survey tool, EM-BCS (Chen et al., 2014), prior to the MPLP to evaluate their beliefs and confidence around mathematical pedagogy and their beliefs of preschoolers' mathematical abilities. Secondary data collected by the organisation on ECTs' Environmental Rating Scale—ERS (ECERS-E and SSTEW) outcome scores were accessed. Data linkage was available for a subgroup of participants to evaluate relationships between ECTs' early mathematics beliefs and confidence survey outcomes and mathematics specific ERS scores. Prior to taking part in the study, participants were provided with information on the study, a participant information statement, and consent form. The study was approved by the Australian Catholic University Human Research Ethics Committee (ethics id: 2021-61E).

Participants

ECTs were recruited from the organisation's 660 long day care centres across all Australian states and territories. All university-trained ECTs (N = 1300) that were working with 3–5-year-old children, across the services, were invited to participate in the study. Figure 1 summarizes participant recruitment procedures and sources of data at the commencement of the program. A convenience sample of 325 participants (n = 320 female, n = 5 male) provided written informed consent to be involved in the study and independently completed the online survey during April 2021. Four participants completed the survey multiple times, where only the first attempt was included as their response. Within the 12-months prior to the online survey, the organisation conducted ERS (ECERS-E and SSTEW) assessments by trained observers for a proportion of ECTs within the organisation. Complete mathematics focussed ERS item scores were available for 277 ECTs (102 participants and 175 non-participants of the MPLP—see Fig. 1). These secondary data were accessed for the period 12-months prior to administration of the survey. Prior to the commencement of the study no mathematics professional learning took place due to challenges presented by the COVID-19 pandemic; staff did not have the capacity to attend training due to the workforce challenges resulting from COVID-19 outbreaks and lockdowns. ECTs who completed the survey in April 2021 and were in the same study centre as their Environmental Rating Scale assessment, were designated as the data linkage group (Cohort 1, n = 102). ECTs who completed the survey but did not have valid ERS data during the previous 12-months were

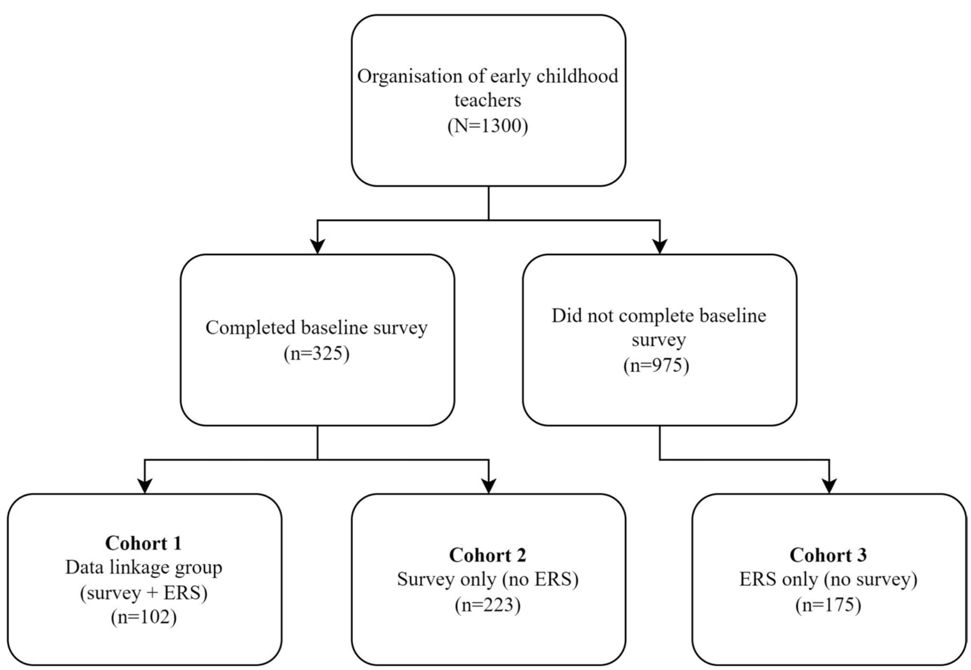


Fig. 1 Participant recruitment procedures and data linkage summary

designated as Cohort 2 (n = 223) and the remaining ECTs who had ERS data but did not participate in the survey were designated as Cohort 3 (n = 175).

Data Collection

Early Mathematics Beliefs and Confidence Survey

The Early Mathematics Beliefs and Confidence Survey (Chen et al., 2014) was completed online using the Research Electronic Data Capture (REDCap: Vanderbilt University, Tennessee) software. The survey consists of 28 questions across three sections: (1) Beliefs About Preschoolers and Math; (2) Confidence in Helping Preschoolers Learn Math: Confidence in Pedagogical Knowledge (Part-A) and Pedagogical Ability (Part-B); (3) Confidence in Your Math Abilities. Each question was answered on a five-point Likert scale: "strongly agree", "agree", "neutral", "disagree", or "strongly disagree". Construct validity has been established for the EM-BCS and internal consistency of each of the three sections has been shown to be high ($\alpha = 0.84$–0.90) (Chen et al., 2014).

Environmental Rating Scale

Environmental quality ratings were conducted by highly trained observers throughout a one-day observation of the ECTs preschool room in the 6-month period before the commencement of the study. Training was conducted in 2018 by Professor Iram Siraj OBE (Oxford University, UK) in her capacity as one of the co-authors of ECERS-E and SSTEW scales (Siraj et al., 2015; Sylva et al., 2003). Consistent with previous studies observers "took a fly-on-the-wall approach to observation, so as to observe (but not influence) typical practice" (Howard et al., 2018, p. 4). Further, given a one-day observation in isolation limits the ability to index typical practices over time, observation days also involved an in-depth review of programming, discussion with key educators and access to other relevant materials.

The ECERS-E was developed by Sylva et al. (2006) to supplement the Early Childhood Environmental Rating Scale (ECERS-R), in response to what they saw as the insufficiently 'cognitive' content of the ECERS-R in its assessment of play-based learning environments. The ECERS-E was designed to be "more sensitive to important pedagogical processes conducive to children's intellectual and social progress" (Sylva et al., 2006, p. 78) in an English curricular context and offers a means of assessing preschool (3–5 years) practice aimed at cultural and intellectual diversity. The ECERS-E consists of 15 items on four subscales that provides greater depth and additional items in four educational aspects of provision, namely (1) Literacy (e.g. opportunities for emergent writing, letters and sounds), (2) Mathematics (e.g. number, reasoning), (3) Science and Environment (e.g. supporting children's creative and critical thinking and understanding of the natural and physical world), and (4) Diversity (e.g. planning for children's individual learning needs, valuing and respecting other cultures, gender diversity). The ECERS-E gives higher scores to pedagogical practices and activities where staff take a more active role in children's learning, including scaffolding young children's play, especially in the communication and literacy domains of the curriculum: 1 indicates *inadequate* quality, 3 indicates *minimal* quality, 5 indicates *good* quality, and 7 indicates *excellent* quality. According to Sylva et al. (2010) items are scored between 1 and 7 with a score of 3 allocated "if the pedagogy seems 'accidental' or lacks coherence", 5 if "the setting shows evidence of adult guidance balanced with child play and/or exploration" and 7 for "pedagogy in which adult and child both contribute to the construction of shared meanings, knowledge and skills" (p. 10).

Validity (Sylva et al., 2006): The ECERS-E has been used extensively in research such as England's Effective Provision of Preschool Education (EPPE) project (1999–2003). To validate the ECERS-E, the EPPE study related ECERS-E scores to scores on the ECERS-R and the Child Caregiver Interaction Scale [CIS, (Arnett, 1989)] (Sammons et al., 2002; Sylva et al., 2003). "Based on data from all 141 preschool centres, a significant strong relationship was found between the ECERS-E and the ECERS-R total scores ($r = 0.78$, $p < 0.01$). Significant moderate relationships were found between the ECERS-E total and two CIS subscales: Positive Relationship ($r = 0.59$, $p < 0.01$) and Detachment ($r = -0.45$, $p < 0.01$). The other two subscales of the CIS (Punitiveness, Permissiveness) were also significantly related to the ECERS-E total in the expected direction, but these relations were weak ($r = -0.18$, $r = -0.32$, $p < 0.05$)" (Sammons et al., 2002 in Sylva et al., 2006, p. 81). Overall, the findings supported the construct validity of the ECERS-E, with stronger correlations with the ECERS-R and weaker (but still significant) correlations with the CIS.

Reliability (Sylva et al., 2006): Inter-rater reliability of the two scales was determined using 25 randomly selected centres throughout the regions. It was calculated in two ways: (a) as the percentage of exact agreement between the two observers and (b) as a kappa coefficient (Cohen, 1968). The analysis was done separately for each region and showed that on the ECERS-R, the percentage of exact agreement ranged from 78.2 to 91.4 while the kappa coefficients ranged from 0.75 to 0.90. The range of the percentages of exact agreement on the ECERS-E was 85.2–97.6 and the range of kappa coefficients was 0.83–0.97. "These results indicate good to excellent inter-rater reliability across centres and regions" (Sylva et al., 2006, p. 81).

The SSTEW scale "describes educational practices that support the development of task focus, problem-solving, and imagination" with the items in the scale consisting of "clearly defined 'indicators', showing an incline of quality in practice" (Siraj et al., 2015, p. 5). There are 7 levels from inadequate (score of 1) to excellent (score of 7). "Items are averaged to yield subscale scores, and the subscales are averaged to generate an overall scale score" (Siraj et al., 2023, p. 8).

Items of interest in ECERS-E and SSTEW in this study were the items related to mathematics and early numeracy. This included:

- ECERS-E Item 7—counting and the application of counting.
- ECERS-E Item 8—reading and representing simple numbers.
- ECERS-E Item 9a—mathematical activities: shape.
- ECERS-E Item 9b—mathematical activities: sorting, matching, comparing.
- SSTEW Scale Subscale 4, Item 9—supporting curiosity and problem solving.
- SSTEW Scale Subscale 4, Item 11—encouraging sustained shared thinking in investigation and exploration.
- SSTEW Scale Subscale 4, Item 12—supporting children's concept development and higher order thinking.

While there were seven ERS items related to mathematics and early numeracy, observers could choose between (i) ECERS-E Item 9a—Mathematical activities: Shape and (ii) ECERS-E Item 9b—Mathematical activities: Sorting, matching, comparing, during their observation.

Data Analysis

Survey data were downloaded from REDCap into Microsoft Excel (Microsoft Corporation, Washington). The five points on the rating scale were labelled (5) strongly agree, (4) agree, (3) neutral, (2) disagree, or (1) strongly disagree with each allocated the corresponding numerical value for statistical analyses. To evaluate teachers' mathematics beliefs and confidence and their influence on ERS outcomes, scores of individual question items 1, 7, and 8 in survey section 1 (Beliefs About Preschoolers and Math) "Data Collection - Early Mathematics Beliefs and Confidence Survey" and items 2, 3, and 7 in survey section 3 (Confidence in Your Math Abilities) "Data Collection - Early Mathematics Beliefs and Confidence Survey" were inversed so that higher scores for all survey items were indicative of greater self-reported early mathematics beliefs and confidence, respectively.

Early Mathematics Beliefs and Confidence

EM-BCS responses and ERS data were summarized using descriptive statistics. A factor analysis (Principal Components Analysis extraction method with Varimax rotation) was performed on the EM-BCS survey item scores. Criteria for retaining survey items in the factor matrix included: (i) eigenvalue > 1.0; (ii) factor loading > 0.6; (iii) communality > 0.5; (iv) three or more survey items per factor; and (v) no cross-loading of items between factors (Hair et al., 2009). The criteria were more stringent than a previous confirmatory factor analysis performed on the EM-BCS (Chen et al., 2014) as we wanted to confirm specific constructs that were representative of our participants' mathematics beliefs and confidence and consolidate the number of survey outcome items for further analyses. Derived factors from the analysis were labelled based on common themes of the retained survey items, ensuring consistency where possible with previous EM-BCS constructs. A mean score was calculated from the retained survey items for each factor, on a scale of 1–5, representing the magnitude of early mathematics beliefs and confidence.

Inter-Relationships Between ECTs' Mathematics Beliefs and Confidence

Normality of participant mathematics beliefs and confidence factor scores were evaluated using the Kolmogorov–Smirnov test to inform the subsequent bivariate correlation method. Survey factor scores were not normally distributed ($p < 0.001$), and therefore, inter-relationships between early mathematics beliefs and confidence factors were evaluated using Spearman rank correlation coefficients (r_s). Spearman correlation coefficients are more robust for non-normally distributed data and potential outliers when compared with Pearson correlation coefficients (de Winter et al., 2016). Spearman coefficients were classified by their strength of association: "very weak" ($r_s = 0$–0.19), "weak" ($r_s = 0.20$–0.39), "moderate" ($r_s = 0.40$–0.59), "strong" ($r_s = 0.60$–0.79), and "very strong" ($r_s = 0.80$–1.0).

Environmental Rating Scale Scores

We analyzed the following ERS items: ECERS-E Items 7, 8, 9b and SSTEW Scale Subscale 4, Items 9, 11 and 12. ECERS-E item 9b was analyzed over 9a as it included a broader range of mathematics concepts and ideas. Pre-MPLP, there were 102 participants (Cohort 1) and 175 (Cohort 3) non-participants with available secondary ERS score data. Individual ERS item scores, and ECERS-E, SSTEW, and ERS total scores were not normally distributed (Kolmogorov–Smirnov test, $p < 0.05$) across both cohorts and therefore ERS descriptive data were presented as median and interquartile range (IQR). Scale scores across the two cohorts were analyzed to determine:

- The median and interquartile range (IQR) for each ECERS-E and SSTEW item for the two cohorts.
- The median and interquartile range (IQR) for ECERS-E total score, SSTEW total score, and ERS total scores (ECERS-E + SSTEW) for the two cohorts.

Do ECTs' Mathematics Beliefs and Confidence Predict Environmental Rating Scale Outcomes?

Before evaluating the association between ECTs' early mathematics beliefs and confidence factor scores and ERS scores, representativeness of the data linkage group (Cohort 1) was determined. Differences in the derived survey factor scores between participants in Cohort 1 and the remaining participants who had completed the survey but did not have ERS data (Cohort 2, n = 223) were evaluated using the Mann–Whitney U test. Differences in secondary data ERS scores and geographical representation across states of Cohort 1 and Cohort 3 were evaluated using the Mann–Whitney U and Chi-square tests, respectively. If no significant between-group differences existed with both comparisons (i.e., Cohort 1 was a representative subgroup of ECTs from the organisation), multiple linear regressions were used to evaluate to what extent ECT's mathematics beliefs and confidence factor scores were predictive of ECERS-E total score, SSTEW total score, and total ERS score. Despite survey factor scores and ERS data not fulfilling the normality assumption of linear regression modelling, we did not plan to manipulate these data (i.e., transformation) as this can instil bias in the model and the number of observations per independent variable was appropriate in this instance (Schmidt & Finan, 2018). Statistical significance for all tests was accepted at $p < 0.05$. Statistical analyses were carried out using SPSS Statistics version 27 (IBM: New York, United States).

Results

Early Mathematics Beliefs and Confidence

On average, ECTs were shown to have positive beliefs and confidence of mathematical pedagogical knowledge and application, and in the mathematical abilities of preschoolers. Table 1 summarizes ECTs' responses for survey section 1 of the EM-BCS, pertaining to beliefs in preschoolers' mathematics abilities. The majority of ECTs had positive beliefs about the capacity of preschool children to learn math and the need to support math learning in a preschool environment to be ready for kindergarten, observed in the response distribution heatmap in Table 1 for items 2–6. Almost all ECTs (~95%) strongly agreed or agreed that preschoolers learn about math through everyday activities. Items with inversed scores (1,7, and 8) were observed to have the greatest variance in participant responses. More than half (59.4%) of the teachers did not agree that most children enter preschool with some math abilities, while approximately two in three teachers do not agree that most preschool children won't require structured math learning (68.9%) via a published math curriculum (61.2%).

Table 1 Early childhood teachers' survey response distribution from the early mathematics beliefs and confidence survey section 1—beliefs in preschoolers' mathematics (Color figure online)

Most children **in my class** ____	Participant (n=325) response distribution per item (%)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. enter preschool with some math abilities[a]	7.1	33.5	21.5	27.7	10.2
2. have the cognitive abilities to learn math	46.8	44.9	7.4	0.6	0.3
3. should be helped to learn math in preschool	53.8	39.1	6.2	0.9	0.0
4. are very interested in learning math	36.0	49.8	12.9	1.2	0.0
5. need to learn math in preschool to be ready for kindergarten	32.6	40.0	16.3	9.5	1.5
6. learn a great deal about math through their everyday activities	63.4	32.3	3.7	0.6	0.0
7. does <u>not</u> need structured preschool math instruction[a]	7.1	24.0	31.1	28.9	8.9
8. should be helped to learn math <u>not</u> using a published math curriculum[a]	8.9	29.8	33.5	17.5	10.2

[a]Questions were modified from the original survey to represent the inverse score for each item

Table 2 Early childhood teachers' survey response distribution from the early mathematics beliefs and confidence survey section 2—teacher confidence in helping preschoolers learn math (Color figure online)

(Part A) I am confident in my **knowledge** of	Participant (n=325) response distribution per item (%)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. what the children in my classroom know about math when they enter preschool	12.0	60.0	22.5	5.5	0.0
2. reasonable math goals for preschoolers	20.6	68.6	9.8	0.9	0.0
3. the best practices and strategies for helping preschoolers learn math	17.5	53.8	25.5	3.1	0.0
4. local or national math standards for preschoolers	22.2	65.5	12.0	0.3	0.0
5. the best ways to assess children's math knowledge and understanding throughout the year	16.0	51.4	26.5	6.2	0.0
(Part B) I am confident in my **ability** to					
6. observe what preschoolers know about math	30.5	63.7	4.9	0.9	0.0
7. incorporate math learning into common preschool situations (such as art or dramatic play)	34.2	57.2	7.7	0.9	0.0
8. plan activities to help preschoolers learn math	32.6	58.8	8.0	0.6	0.0
9. further preschoolers' math knowledge when they make spontaneous math comments/discoveries	28.6	61.2	8.9	1.2	0.0
10. make sense of preschoolers' confusions when they learn math	21.8	58.2	16.9	3.1	0.0
11. translate assessment results into curriculum plans	17.2	49.2	29.5	3.7	0.3

Table 2 summarizes ECTs' responses for survey section 2 of the EM-BCS, pertaining to confidence in early mathematics pedagogical knowledge and pedagogical ability in helping children learn mathematics. On average, teachers were confident in their knowledge of children's baseline mathematics abilities, goal setting, and strategies for effective mathematics teaching practice and assessment. Similarly, the majority of teachers were confident in their ability to observe, plan, engage with and support preschoolers' mathematics learning (e.g., incorporate math learning into common preschool situations and translate assessment results into curriculum plans).

Table 3 summarizes ECTs' responses for survey section 3 of the EM-BCS, pertaining to self-confidence in their own mathematics abilities. While the majority of ECTs were confident in their pedagogical knowledge and ability to help children learn mathematics, there existed a range of responses related to perceptions of their own mathematics abilities, with greater 'disagree/strongly disagree' frequencies compared with survey sections 1 and 2.

Five unique math beliefs and confidence factors were derived from the factor analysis of the EM-BCS responses, reducing the 28-item survey to 21 items specific to early mathematics beliefs and confidence of our cohort (Table 4). The factors showed consistency with the previously established EM-BCS constructs, with each of the five unique factors being loaded with items from only one of the three survey sections. Factor 3 was the most robustly derived factor with communalities above 0.7 for all three included items.

The five derived factors were labelled: (1) confidence in helping children learn math; (2) confidence in personal math skills; (3) personal views about math; (4) beliefs around not using a structured preschool math curriculum; and (5) confidence in children's math learning. Figure 2 illustrates relationships between included survey items from Table 4 and the labelled factors, arranged according to their EM-BCS section and factor loading size. Mean (standard deviation) survey scores (1–5 scale) of included items in each factor were: Factor 1—4.04 (0.53); Factor 2—3.37 (0.74); Factor 3—3.26 (1.03); Factor 4—3.31 (0.56); and Factor 5—4.39 (0.51). Mean scores for Factors 1 and 5 were between "agree" and "strongly agree" on the five-point Likert scale, indicative of high teacher confidence in helping children learn math and in children's math learning ability. Factors

Table 3 Early childhood teachers' survey response distribution from the early mathematics beliefs and confidence survey section 3—teacher confidence in their personal math abilities (Color figure online)

Confidence in Personal Math Abilities	Participant (n=325) response distribution per item (%)				
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1. Math was one of my best subjects in school	15.7	23.4	23.1	28.9	8.9
2. The word "math" does not make me feel nervous[a]	16.0	38.2	22.5	19.1	4.3
3. I'm a "math person"[a]	15.7	32.9	20.9	24.6	5.8
4. I can easily rotate objects in my mind	9.8	38.8	33.5	14.5	3.4
5. I like coming up with creative ways to solve math problems	14.2	42.8	27.4	13.8	1.8
6. I can easily convert fractions into percentages and decimal numbers	10.2	28.0	23.7	26.8	11.4
7. I have a good sense of direction[a]	16.0	32.6	21.2	19.4	10.8
8. I'm good at looking at numeric data and finding patterns	9.5	37.2	32.9	16.6	3.7
9. I'm good at estimating how tall something is or the distance between two locations	8.6	34.8	29.8	20.9	5.8

[a]Questions were modified from the original survey to represent the inverse score for each item

2–4, however, had lower mean scores than Factors 1 and 5, which were between "neutral" and "agree". Furthermore, there was greater variance in survey responses around personal math abilities (EM-BCS section 3), as evidenced by larger standard deviations for confidence in personal math skills and personal views about math compared with the other factors.

Inter-Relationships Between Mathematics Beliefs and Confidence Factors

Inter-relationships between the derived math beliefs and confidence factors were evaluated using Spearman's correlation coefficient (Table 5). Confidence in personal math skills and personal math views showed the largest association between factors across our cohort, with a moderate positive association found ($r_s = 0.56$). Confidence in helping preschoolers learn math was shown to have very weak to weak associations with the other four factors.

Environmental Rating Scale Scores

Cohort 1 had representative ERS scores, and similar geographical distribution compared with other ECTs in the organisation that did not participate in the MPLP (Table 6). Median scores for individual ERS mathematics items across all ECTs ranged 2–3 out of 7, with 3 indicating *minimal* quality ("if the pedagogy seems 'accidental' or lacks coherence") (Sylva et al., 2006, p. 10).

Relationships Between Mathematics Beliefs and Confidence and Environmental Rating Scales

Before determining the relationship between ECTs' mathematics beliefs and confidence and ERS outcomes, we needed to determine if Cohort 1's views were representative of other ECTs in the organisation. Survey factor scores of Cohort 1 were not significantly different to Cohort 2 (helping preschoolers learn mathematics $U = 10{,}156.5$, $p = 0.120$, personal mathematics skills $U = 10{,}675.0$, $p = 0.371$, personal views about mathematics $U = 9911.0$, $p = 0.062$, preschool mathematics curriculum $U = 12{,}044.9$, $p = 0.386$, children's mathematics learning $U = 11{,}467.0$, $p = 0.903$).

From the multiple linear regression results it was found that 18.4% ($_{adjusted}R^2 = 0.184$) of variance in ECERS-E can be accounted for by the five ECT's mathematics beliefs and confidence factors derived from the exploratory factor analysis, $F(5,46) = 3.30$, $p = 0.013$ (i.e., beliefs and confidence had a weak association with ECERS-E score). When looking at individual contributions of each variable, beliefs around *not* using a structured mathematics curriculum in preschool are negatively associated with ECERS-E scores ($\beta = -0.47$, $t = -3.51$, $p = 0.001$) and *was the only independent variable significantly associated with ECERS-E*, i.e., greater beliefs

Table 4 Factor analysis of the early mathematics beliefs and confidence survey (n = 325)

Survey items	Factor loading					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
Section 1. *Most children in my class ____*						
1. Enter preschool with some math abilities[a]						
2. Have the cognitive abilities to learn math					0.731	0.590
3. Should be helped to learn math in preschool						
4. Are very interested in learning math					0.726	0.591
5. Need to learn math in preschool to be ready for kindergarten				− 0.749		
6. Learn a great deal about math through their everyday activities					0.702	0.539
7. Does not need structured preschool math instruction[a]				0.817		
8. Should be helped to learn math not using a published math curriculum[a]				0.784		
Section 2. (Part A) *I am confident in my knowledge of*						
1. What the children in my classroom know about math when they enter preschool						
2. Reasonable math goals for preschoolers						
3. The best practices and strategies for helping preschoolers learn math	0.663					0.671
4. Local or national math standards for preschoolers						
5. The best ways to assess children's math knowledge and understanding throughout the year	0.646					0.652
Section 2. (Part B) *I am confident in my ability to*						
6. Observe what preschoolers know about math	0.705					0.558
7. Incorporate math learning into common preschool situations (such as art or dramatic play)	0.757					0.636
8. Plan activities to help preschoolers learn math	0.827					0.724
9. Further preschoolers' math knowledge when they make spontaneous math comments/discoveries	0.845					0.750
10. Make sense of preschoolers' confusions when they learn math	0.782					0.639
11. Translate assessment results into curriculum plans	0.683					0.554
Section 3. *Confidence in personal math abilities*						
1. Math was one of my best subjects in school			0.687			0.715
2. The word "math" does not make me feel nervous[a]			0.887			0.836
3. I'm a "math person"[a]			0.850			0.839
4. I can easily rotate objects in my mind		0.700				0.519
5. I like coming up with creative ways to solve math problems		0.619				0.549
6. I can easily convert fractions into percentages and decimal numbers						
7. I have a good sense of direction[a]						
8. I'm good at looking at numeric data and finding patterns		0.684				0.616
9. I'm good at estimating how tall something is or the distance between two locations		0.752				0.619

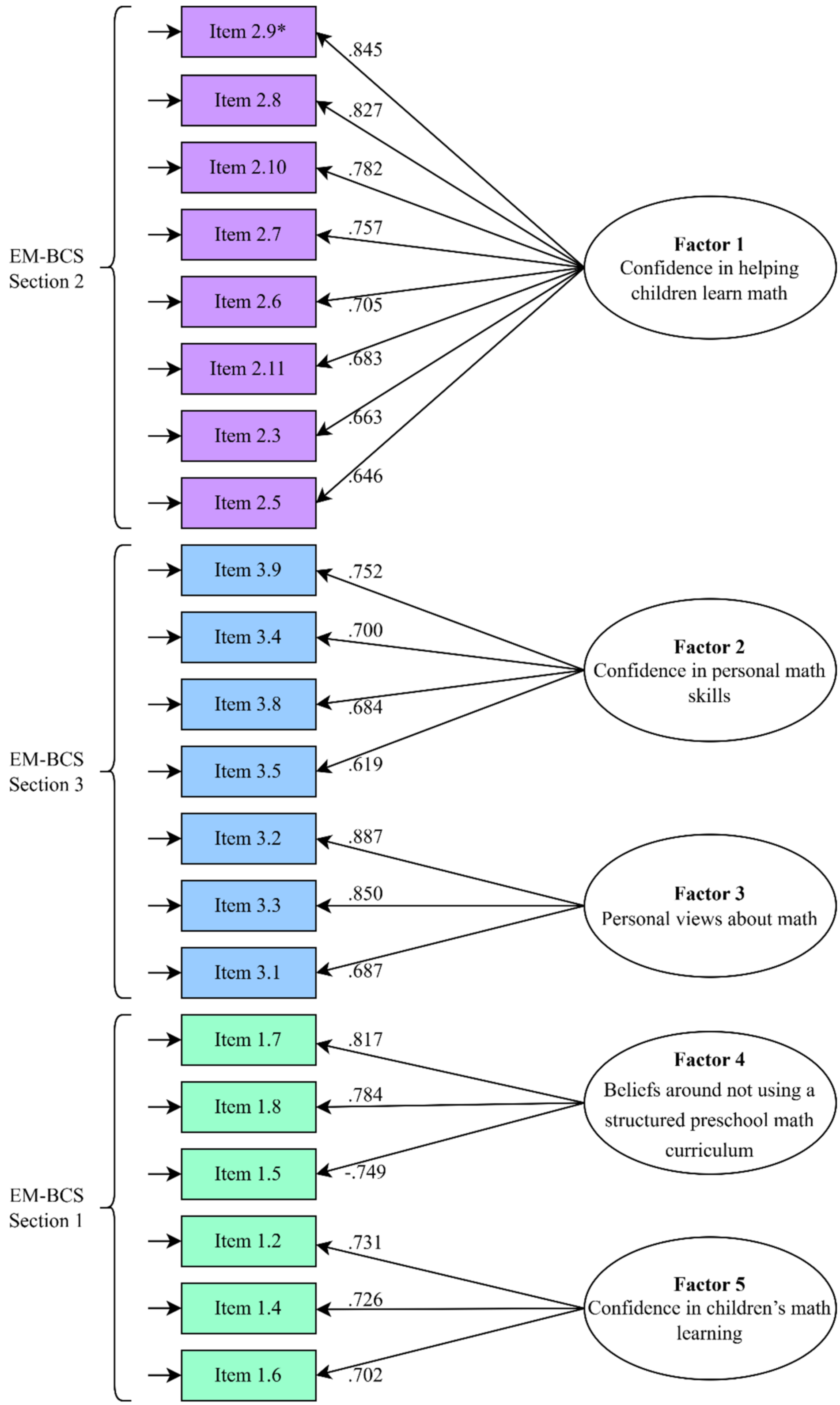
Factor loadings and communalities were only displayed for items that met the criterion: (i) eigenvalue > 1.0; (ii) factor loading > 0.6; (iii) communality > 0.5; (iv) three or more survey items per factor; and (v) no cross-loading of items between factors

[a]Questions were modified from the original survey to represent the inverse score for each item

in *using* a structured math curriculum predicted better ERS outcomes. Early childhood teacher's confidence in helping children learn math ($\beta = -0.23$, $t = -1.37$, $p = 0.177$), confidence in personal math skills ($\beta = 0.02$, $t = 0.11$, $p = 0.917$), personal views on mathematics ($\beta = 0.18$, $t = 1.30$, $p = 0.201$), and confidence in children's mathematics learning ($\beta = 0.13$, $t = 0.84$, $p = 0.404$) *were not significantly associated with ECERS-E*. Multicollinearity of the five variables in the model was not a concern (Variance Inflation Factor = 1.11–1.73).

ECT's mathematics beliefs and confidence did not predict SSTEW outcome scores: ${}_{adjusted}R^2 = 0.020$, $F(5,46) = 1.21$, $p = 0.319$. Furthermore, no individual factor was significantly associated with SSTEW scores: confidence in helping children learn math ($\beta = 0.33$, $t = 1.79$, $p = 0.08$); confidence in personal mathematics skills ($\beta = -0.12$, $t = -0.74$, $p = 0.464$), personal

Fig. 2 Factor loading path diagram of included EM-BCS items and their relationships with the derived factors



*Item 2.9 corresponds to EM-BCS section 2, question 9

Table 5 Inter-relationships between ECTs' Early Mathematics Beliefs and Confidence Factor Scores

Factor analysis score	Spearman's correlation coefficient (r_s)				
	Helping preschoolers learn math	Personal math skills	Personal views about math	Preschool math curriculum	Children's math learning
Helping preschoolers learn math	1.00				
Personal math skills	0.31***	1.00			
Personal views about math	0.21***	0.56***	1.00		
Preschool math curriculum	− 0.13*	− 0.07	− 0.04	1.00	
Children's math learning	0.32***	0.09	0.02	0.08	1.00

*$p < 0.05$

***$p < 0.001$

Table 6 ERS Scores for Participants and Non-participants of the MPLP

Outcome	Cohort 1 (n = 102)	Cohort 3 (n = 175)	Between group statistic
State/territory (%)			
ACT	2.0	1.7	$X^2 = 10.54$, $p = 0.16$
NSW	37.3	30.9	
Queensland	38.2	33.7	
South Australia	6.9	10.9	
Tasmania	0.0	0.6	
Victoria	13.7	12.6	
WA	2.0	2.3	
Not reported	0.0	7.4	
ECERS-E median (IQR)			
Item 7	3 (2)	3 (2)	$U = 8187.5$, $p = 0.24$
Item 8	2 (2)	2 (3)	$U = 9014.0$, p = 0.88
Item 9b	3 (2)	3 (2)	$U = 8561.0$, p = 0.56
Total	8 (4)	8 (4)	$U = 8566.5$, p = 0.58
SSTEW median (IQR)			
Item 9	3 (2)	3 (2)	$U = 8522.0$, $p = 0.52$
Item 11	3 (2)	2 (2)	$U = 8956.5$, p = 0.96
Item 12	3 (2)	3 (2)	$U = 8758.0$, p = 0.79
Total	9 (6)	9 (6)	$U = 8874.5$, p = 0.94
ERS total median (IQR)	16 (10)	17 (9)	$U = 8569.5$, $p = 0.58$

IQR interquartile range, *X* Chi-square test, *U* Mann–Whitney *U* test

views on mathematics ($\beta = -0.01$, $t = -0.05$, $p = 0.963$); beliefs around not using a structured mathematics curriculum in preschool ($\beta = -0.16$, $t = -1.09$, $p = 0.283$); confidence in children's mathematics learning ($\beta = -0.01$, $t = 0$–0.07, $p = 0.946$). Multicollinearity of the five variables in the model was not a concern (Variance Inflation Factor = 1.03–1.54).

Discussion

We aimed to explore ECTs' early mathematics beliefs and confidence. The majority of ECTs had positive beliefs about the capacity of preschool children to learn mathematics and the need to support mathematics learning in a preschool environment. Teachers' confidence and beliefs towards helping preschoolers learn mathematics were high particularly around their knowledge to set reasonable mathematics goals for preschoolers which was consistent with Chen et al (2014) findings where the majority (85.8%) of the teachers in their study were confident that they knew reasonable mathematics goals for preschoolers. Our results also indicate that the survey was highly applicable to Australian ECTs, with consistency between our derived factors and the original EM-BCS constructs. In addition to a deeper understanding of ECT's self-reported beliefs and confidence around mathematics, we explored relationships between these constructs and their potential impact on the quality of the teaching and learning environment.

An inter-relationship in our study was found between teachers' beliefs of their own mathematical content and pedagogical knowledge, and their beliefs of preschoolers' mathematical abilities—suggesting that if teachers are confident in their own knowledge and understanding of mathematics, then they are more likely to believe children are capable mathematics learners. Preschool teachers' practices are influenced by their beliefs and values—they inform the choices teachers make about what to plan and implement and are strongly associated to their personal beliefs about mathematics content and pedagogy (Brown, 2005). Beliefs about the value of learning in any area also influences teacher motivation and behaviour and thus their approach to teaching. The belief that young children are capable of learning mathematics and the relevance or value of mathematics for young children are crucial aspects of effective teaching and learning in the subject (Downton et al., 2020). However, there was a spread of responses in our study related to children's mathematics abilities when entering preschool with only two in five ECTs agreeing that children enter preschool with some mathematics abilities. Further investigation is required to determine factors that influence this belief and if greater perceptions around children's existing mathematical abilities relates to a deeper teacher knowledge of mathematical content knowledge. It can be inferred that with greater mathematical content knowledge teachers can 'see' the mathematics children understand and use in their play and the mathematical knowledge children express in their conversations and interactions with others.

To effectively 'see' the mathematics children understand, ECTs require their own mathematics competency (Ball et al., 2008). There was greater variance in ECTs confidence in their personal math skills and personal views about math when compared with the other factors; almost half of ECTs agreed that the word "math" makes them feel nervous. Confidence in their own mathematical abilities were low compared with their confidence in mathematics pedagogical knowledge and application. This included fundamental mathematical concepts such as numeracy and spatial awareness (e.g., object rotation, directional sense). These findings could suggest the presence of MA, which manifests as low confidence and self-efficacy specific to mathematics and can be evident in children as young as six years and continue into adulthood, occurring more often amongst females (Maloney, 2016). Research has found evidence of long-standing MA amongst significant numbers of ECTs internationally (Boyd et al., 2014; Geist, 2015; Gresham & Burleigh, 2019; Jenßen, 2021; Lavidas et al., 2023). While MA in ECTs does not necessarily mean they place less value on mathematics for young children's learning, MA does tend to lead to avoidance of mathematical teaching (Gresham & Burleigh, 2019). This avoidance can be problematic in early childhood settings where the requirements for specific subject-based learning and teaching are less prescribed by curriculum and frameworks, potentially limiting children's experience and learning (Jenßen, 2021)—consistent with the quality of mathematics teaching environments that were found in our study. There is also evidence that MA in teachers can lead to lower expectations for children in mathematics (Gresham & Burleigh, 2019); many ECTs in our study believed that children did not enter preschool with some mathematics abilities. MA can develop where individuals have struggled with basic mathematical building blocks that impede success: certainly, the anxiety that develops itself leads to difficulties in mathematics (Maloney, 2016). There is a clear need for ECTs to be conscious of MA and pre-existing mathematics attitudes and how it may impact their teaching, and for professional learning providers to actively address MA within their professional learning content (Gresham & Burleigh, 2019).

Our study brings a novel perspective to the impact of ECTs' mathematics beliefs and confidence on the quality of the teaching and learning environment as measured by ECERS-E and SSTEW. The ECTs had high beliefs and confidence around early childhood mathematics pedagogy and of preschoolers' capacity to learn mathematics, yet ERS scores for the 6 items related to mathematics and early numeracy were low. The only factor that was independently related was the use of a 'published' mathematics curriculum and a structured preschool mathematics instruction approach, in ECERS-E. It is not surprising that this factor had an association with ECERS-E and not SSTEW, as ECERS-E identifies aspects of curricular quality such as mathematics learning and SSTEW identifies practices that develop skills in sustained shared thinking and emotional wellbeing. Overall, our ECTs had conflicting beliefs related to a published curriculum and structured instruction approach. This conflict could be explained by reported tensions in the research literature where high value is placed on a play-based, social pedagogy and where any movement to increase discipline content and processes, such as mathematics, can be interpreted as a 'push-down' curriculum from school or a shift to a 'school readiness' approach (Anders & Rossbach, 2015; Ang, 2014; Areljung, 2019; Barenthien et al., 2020; Björklund et al., 2020). Despite a weak association found with ECERS-E, beliefs and confidence of ECTs overall were not good predictors of ERS scores suggesting that they may not be enough on their own.

While beliefs and confidence in teacher's own ability (Stipek et al., 2001) and that of children is important (Ginsburg & Ertle, 2008), other factors such as mathematical CK and PCK (Figueiredo et al., 2018), organizational and pedagogical leadership (Gibbs, 2022) and high-quality teacher training and professional development (Piasta et al., 2015) also impact the quality of teaching practices. Mathematical CK and PCK are required for ECTs to "support children initiatives and plan curricular/didactic activities and at the level of the knowledge children interact within their daily environment and routine" (Figueiredo et al., 2018, p. 2). Enhancing ECTs' mathematical CK and PCK have the potential to improve ERS scores of the 6 items related to mathematics and early numeracy. This could have implications for teacher professional learning and content within professional development training. However, if ECTs feel confident in their mathematics knowledge and pedagogy, they may be less likely to access mathematics professional learning as they may not perceive the need to further develop their skills and knowledge in this area.

Limitations

The survey is based on self-reported data and is therefore subjective, reflecting the participant's willingness to share their true beliefs. This is particularly relevant for this cohort where the funding body for the study was the same organisation all the teacher participants were working. The teachers may have felt compelled to respond more positively. To alleviate any pressure, it was made clear to participants that all responses were deidentified and were aggregated and that the findings of the survey would help inform the MPLP to be implemented with all participants. We were unable to explore sub-group differences (e.g., years of experience, education level and more detailed demographics) in mathematics beliefs and confidence and ERS scores. Such diversity data could be useful in future research to determine if certain subgroups have different experiences or perspectives which could have impacted both their survey responses and ERS scores.

In considering the size of the organisation involved in the study and the number of early childhood teachers within the organisation (N = 1300), there was a relatively low survey response rate (25%). This could be attributed to the COVID-19 pandemic, and the related workforce stresses and workforce shortages experienced in the sector at the time (McFarland et al., 2022).

While mathematical CK and PCK may have the potential to improve ERS scores of the mathematics and early numeracy items, further investigation, including measurement of these constructs, is needed to establish a clear link between improvements in CK and PCK and higher ERS scores. Further, in linking ERS data to survey data it was evident that using secondary data from a single organisation is a limitation. Not all participants who completed a survey had ERS scores and data for all 6 items related to mathematics and early numeracy were not observed. Therefore, scores across two distinct groups of ERS scores were analyzed. Further research is also required with a larger sample and comparison with other organisations to validate our findings.

Conclusions and Implications

Chen et al. (2014) suggest that teacher confidence in mathematics pedagogy can be addressed by targeted professional learning. While we agree that addressing teacher confidence and associated MA is important, the findings of our study suggest, that ECTs' confidence in mathematics pedagogy may not be enough to ensure quality mathematics teaching and learning environments. ECTs may be unaware of the specific mathematical content knowledge and pedagogical content knowledge required to effectively teach mathematics to preschool children and develop children's complex mathematical thinking ('you don't know what you don't know'). There is a perception that teaching mathematics in the early years is easy and straightforward, and this may provide a false sense of confidence among ECTs in their mathematics pedagogy however, early mathematics is "abstract, complex, and foundational" (Chen et al., 2014, p. 374) and therefore requires a deep teacher understanding of foundational mathematical content knowledge including a deep understanding of the big ideas of mathematics (Charles & Carmel, 2005). "Big Idea is a statement of an idea that is central to the learning of mathematics, one that links numerous mathematical understandings into a coherent whole" (Charles & Carmel, 2005, p. 10). These big ideas include pattern and structure where relationships can be described and generalisations made for mathematical situations that have items such as objects, shapes or numbers that repeat in predictable ways (Papic et al., 2011).

While ECTs may have positive beliefs around children's capability to learn mathematics they also need to have beliefs that children entering their preschool classroom come with pre-existing mathematical skills, knowledge and understanding. Recognizing the mathematical knowledge and understanding children already possess when they enter a preschool classroom supports teachers to create quality learning environments that provide opportunities for mathematical investigation and learning that supports each child's mathematical development.

Environmental Rating Scales are valuable in measuring quality, and the changes in quality over time however, the findings of this study suggest that mathematics professional learning focused on developing mathematical content knowledge and pedagogical content knowledge of ECTs could be embedded within any ERS training to ensure ECTs' provide an optimal environment for children's mathematics learning, and effective engagement and communication between the teacher and child to develop mathematical thinking.

While children learn mathematics in and through their play, they can learn much more with "artful guidance and challenging activities provided by their teachers" (Moss et al., 2016, p. 162). The findings of this part of the study along with relevant research literature informed the design of a 12-month *online Mathematics Professional Learning Program (MPLP)* focused on developing participant ECTs' mathematical content and pedagogical content knowledge including an understanding of the big ideas of mathematics such as patterns and structure, and spatial thinking. The impact of MPLP on ECTs' post-professional learning ERS scores was the focus of the next part of this study.

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Author Contribution Author 1 ensured study conception and design. Author 1 and 2 contributed to the analysis and interpretation of data and drafted the paper.

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Declarations

Conflict of Interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval and Consent to Participate This study received ethics approval from the Australian Catholic University Human Research Ethics Committee (HREC) (Ref No: 2021-61E). All methods were carried out in accordance with relevant guidelines and regulations provided by the Australian Catholic University's HREC. Informed consent was received from all participants upon their recruitment for this study.

Consent for Publication Informed consent was obtained from all individual participants included in the study.

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