Conceptualising Early Mathematics

Report from the PLÉ Early Childhood Mathematics Special Interest Group

1st May 2024

Acknowledgement

The Mathematics Special Interest Group (SIG) is a dedicated space where members of PLÉ can investigate questions related to mathematics in early childhood education and care. The Maths SIG acknowledges the generous financial and collegial support received from PLÉ, particularly in relation to completing this research and this report.

PLÉ is the Association of Academics in Early Childhood Education and Care in Higher Education in Ireland. It is a voluntary body committed to the advancement of Early Childhood Education and Care, through research, scholarship, teaching and professional networking. PLÉ is an important policy actor, contributing to the development if state policy related to ECEC in Ireland. Member HEIs of PLÉ include Institutes of Technology, Technological Universities as well as traditional Universities in Ireland. PLÉ operates an organisational membership structure, recognising all academics involved in ECEC degree courses within affiliated institutions, as members.

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Executive Summary

In May 2024 Early Childhood Lecturers from across the Republic of Ireland met at the *Conceptualising Early Mathematics* conference in Dublin City University. Facilitated by the PLÉ Early Mathematics Special Interest Group, participants came together to explore three questions significant for the future of mathematics in early childhood degree programmes and in turn, the provision of mathematics in early childhood settings. These questions were: 1) how appropriate is Mathematics in early childhood? 2) What level of Mathematics self-efficacy do PLÉ members possess? 3) What mathematics content should be excluded from / included in EC degree programmes? Findings are discussed under these headings.

Key Findings

1. **How appropriate is Mathematics in early childhood?** There is strong consensus that mathematics is appropriate in early childhood education. Participants reported that mathematics is 'essential' 'very important' and 'appropriate from birth'. There was general agreement that mathematics is an important element of early childhood education, but that its conceptualisation differs considerably from mathematics education in the later stages of the education continuum. The focus in early childhood remains firmly on the use and application of mathematics in daily life, rather than a focus on formal learning or teaching of mathematics.
2. **What level of Mathematics self-efficacy do PLÉ members possess?** Participants generally reported high levels of math self-efficacy. The group identified that specific mathematic knowledge *is* required by lecturers to support EC undergraduates' mathematical content knowledge (MCK) and pedagogical content knowledge (PCK).

This specific knowledge included a clear concept of what EC math entails and the distinction between mathematics as a subject or knowledge area, and numeracy as it applies to everyday life. While ECE educators support numeracy, they must possess mathematical knowledge to notice, identify and respond to the mathematics observed, either in the moment or plan enhancement. Despite the fact that participants generally reported high levels of math self-efficacy, they also frequently mentioned maths anxiety, fear and low confidence and participants identified further support that would be welcomed.

3. **What mathematics content should be excluded from / included in EC degree programmes?** There was strong consensus that directive, adult led, didactic or formal approaches to mathematics should be excluded from EC degree programmes. Despite this, there was enthusiasm for the *intentional inclusion* of mathematics in EC. Discussions centred around the provision of math that supported embodied cognition of mathematics, applied to children's play and routines, and exposed children to a variety of mathematics topics.

Recommendations

Mathematics is an important element of early childhood education and care. A number of recommendations arose from the reconceptualised mathematics event on 1st May 2024 and were reviewed by PLÉ members in early December 2024. Recommendations include:

1. EC mathematics should be given the same level of importance as literacy on EC undergraduate programmes. In order to achieve this, the visibility of mathematics on EC programmes and clarity about how this is conceptualised, is required.

2. Specific knowledge, skills and pedagogy are required to support young children's fundamental math skills. Therefore, EC degree programme in ROI should include this mathematic content on their programmes.
3. A distinction should be drawn between mathematics and numeracy. As educators we require a high level of mathematics knowledge (content and pedagogical) in order to notice, identify and support numeracy in EC settings.
4. A standalone mathematics module on all EC degree programmes would be welcomed. The breadth and depth of math content that young children are capable of is unlikely to be covered within partial or blended modules such as STEM or *Literacy and Numeracy*.
5. The group recommended that a greater focus on the birth to 3-years age range was required. This may include carrying out empirical research, scientific literature reviews or designing and facilitating professional learning events focused specifically on babies and toddlers.
6. Lecturers require more support in relation to EC mathematics, as for many, this content was not included in their own pre-service education. Recommendations about provision of resources, communities of practice and information sharing systems were made and will be enacted by the PLÉ SIG subject to funding.

Introduction

PLÉ the National Association of Higher Education Institutions offering Degree Level Training in Early Childhood Care and Education in the Republic of Ireland (ROI) is concerned with three core and interrelated aspects of ECEC which are 1) the quality of initial educator training; 2) the quality of children's experiences in settings and, 3) the professionalisation of the ECEC workforce (Moloney et al., 2020). The number of institutions delivering EC degree programmes in ROI has risen considerably. Increased focus on ECE over the past few decades has led to greater scrutiny on EC educators' initial education and attempts to influence content of degree programmes have increased (see DES, 2019 for details).

The Early Childhood (EC) Mathematics special interest group (SIG) was established in 2019. Within academia, a special interest group is a sub-group within a larger organisation, whose members typically possess a shared interest in advancing a specific area of knowledge. The PLÉ EC mathematics SIG was created to provide a community of practice for those teaching on EC degree programmes whose work, research, teaching, or personal interests include early childhood mathematics. The SIG aims to bring together lecturers from across Ireland to share knowledge and understanding about EC mathematics.

Having chaired the EC mathematics SIG for a number of years, SIG convenors Sandra O'Neill (DCU) and Córa Gillic (DCU) identified a growing interest in EC mathematics among PLÉ members and from government departments with responsibility for EC. Since 2016, EC Mathematics (and STEM more generally) is situated firmly on the EC policy agenda appearing explicitly in numerous government publications including:

1. Specific mathematics criteria in the updated Early Years Education Focused Inspection Tool (Department of Education, 2022)

2. The STEM education policy statement and implementation plans (Department of Education, 2023; Department of Education and Skills, 2017b, 2017a)
3. The updates Literacy, Numeracy and Digital Literacy Strategy (Government of Ireland (GOI), 2024)
4. A literature review to support the redevelopment of Aistear (French & McKenna, 2022)
5. Increased reference to numeracy and mathematics in Aistear (NCCA, 2024)

Research carried out in ROI points to a lack of EC mathematics content in initial educator training. Educators report that mathematics is included in less than 40% of EC initial education programmes (O'Neill et al., 2023) while requirements to understand and support this subject matter is increasing (Department of Education, 2022; Department of Education and Skills, 2019). As such, in early 2024 the PLÉ Early Childhood Mathematics SIG came together to investigate members perspectives on these changes and formally conceptualise our understanding of EC mathematics in ROI.

Rationale

What is possible and desirable in EC mathematics is the subject of ongoing debate. Mathematics is not central to EC curriculum but growing evidence that EC mathematics is important for young children's later academic success (Duncan et al., 2007; Watts et al., 2018) has sparked debate on the matter. Opinions vary about how EC mathematics content should be designed, what constitutes appropriate content (Palmér & Björklund, 2016) and how, or if, the learning of maths concepts should be supported by adults. Research shows that many early childhood educators believe that maths education should be delayed until formal schooling (Knaus, 2017) and that socio-emotional development is more important in EC. Educators' understanding of EC mathematics tends to be superficial and limited to shape and rote

counting (Hachey, 2013; Varol, 2013) with little consideration given to maths processes such as reasoning, explaining, thinking aloud, justification and mathematising (National Research Council, 2009). The world is a mathematical place, and children's natural curiosity and wonder enables them to discover and investigate mathematical concepts simply by participating in everyday experiences (O'Neill et al., 2022). Using mathematical language, framing and concepts to explore situations that arise in everyday activity and play support children to become confident and competent problem solvers and mathematicians.

In Ireland, challenges with the provision of early mathematics have been highlighted across the birth to 8-year-old age range. Research has identified that provision in pre-school and stage 1 (Junior and Senior Infants) of primary school has their own unique issues. While teachers in junior primary classes are guaranteed early mathematics modules as part of their preservice education, there is a lack of understanding about the role of talk and discussion in mathematics pedagogy and the need to focus on mathematical processes (e.g., problem solving, reasoning, proof, communication) and dispositions (e.g., curiosity, persistence) (Dunphy, 2009). However, in the same study Dunphy found that teachers *are* competent in the delivery of mathematics content and that structural issues (class sizes and curriculum overload) impact teacher's ability to deliver play-based math lessons. In EC settings concerns raised about math provision pertain to the capacity of the workforce to provide the kinds of experiences needed to secure optimal mathematics learning (Dunphy, 2018). Despite calls for the inclusion of more specific math content in pre-school frameworks (French & McKenna, 2022; O'Neill et al., 2022) most EC educators report a low level of mathematics provision in their preservice education (O'Neill et al., 2023). Knowing how crucial the years before compulsory education are for children's mathematical understanding and later overall academic achievement (Duncan et al., 2007; Nguyen et al., 2016; Watts et al., 2018) this gap in EC educators' knowledge is concerning. Dunphy argues that serious consideration should be given to the inclusion of mathematics in EC preservice programmes stating

> "Questions must be asked about how practitioners define mathematics skills and numeracy, how they understand mathematics education for young children, what mathematics they think young children can learn, what teaching and learning strategies they think are appropriate, how they view intentional teaching of early mathematics, and how they understand the role that play has in developing mathematical understanding. Central to educators' capacities to develop young children's mathematical dispositions, knowledge, skills, and understandings are their conceptual frameworks of how children develop in this area of learning and how best to support it. This is often referred to as mathematical knowledge for teaching. This knowledge is as essential for preschool educators as it is for primary school teachers"(Dunphy, 2018, p. 109)

While traditionally EC curricula included mathematics (for example, see Montessori math materials and Froebel's gifts) this has fallen out favour in recent decades. Piaget's conceptualisation of children's normative developmental stages gave rise to the idea that children develop conceptual knowledge at specific times in their lives, and no sooner. As such, the role of the adult in supporting mathematics was considered superfluous to the child's normative and natural development (Hedges, 2014) and incidental mathematics became the norm in EC settings. Mathematics as an element of EC preservice training was therefore, eroded. Perhaps as a consequence of the limited math content in this stage of education, early childhood has been labelled a 'math avoidant profession' (Jenßen, 2021).

Maths anxiety is a widespread problem which can lead to negative educational consequences (Luttenberger et al., 2018) and educators' math anxiety can impact children's math achievements (Park et al., 2024; Ramirez et al., 2018). In some studies up to half of pre-service EC educators report low enjoyment and low self-efficacy in relation to mathematics (Blömeke et al., 2019). As maths anxiety and maths avoidance have been found to be closely correlated (Choe et al., 2019) and EC teachers' knowledge and anxiety in mathematics are negatively related (Jenßen et al., 2020) the ongoing lack of mathematics provision in EC degree programmes is concerning. While children in compulsory education have a set mathematics

curriculum, preschool settings in ROI use a curriculum framework. Aistear's (NCCA, 2009) structure as curriculum framework provides great flexibility in responding to the interests and needs of children and enables educators' agency and professional autonomy. While these are strengths of Aistear, when dealing with a 'math avoidant profession' its structure also facilitates maths avoidance and may restrict the amount of mathematics young children are exposed to. If significant numbers of EC educators report maths anxiety and poor self-efficacy, PLÉ must consider the consequences of not establishing a clear approach to mathematics in EC degree programmes. Literature investigating the causal ordering between math avoidance and math anxiety is somewhat inconclusive but confirms that cycles of math anxiety, math avoidance and further math anxiety are commonplace (Carey et al., 2016; Ma & Xu, 2004). At the very least preservice education must allow educators to confront their own beliefs and attitudes in relation to mathematics and assess the impact of these on the experiences provided for children in their care.

In addition to exploring maths beliefs and attitudes preservice educators also need to strong content knowledge. While the research base is still somewhat limited, literature suggests that expanding EC educators' math knowledge enhances their confidence and in turn leads to more mathematics provision in their setting (Geist, 2015). The provision of enjoyable and successful experiences of mathematical activities in preservice education therefore could be a way to counter maths anxiety, maths avoidance and poor self-efficacy (Blömeke et al., 2019).

The term numeracy is favoured in early childhood policy documents in the ROI. For example, Aistear the early childhood curriculum framework for EC defines numeracy as 'developing an understanding of numbers and mathematical concepts' (National Council for Curriculum and Assessment [NCCA], 2009, p.56). The distinction between the terms *mathematics* and *numeracy* highlights some of the debate pertaining to EC mathematics. Mathematics is typically understood as a knowledge domain and associated with formal learning, while

numeracy stresses the socio-cultural perspective involved for discovering, thinking about, and applying mathematical knowledge in children's everyday lives (O'Neill et al., 2022). When discussing numeracy in early childhood MacDonald et al. (2018) emphasise the importance of context, purpose, and usefulness of mathematics in meaningful real-world experiences. The EC mathematics SIG favours this broader definition of numeracy that encompasses the way in which children use mathematics in their everyday lives and emphasises a hands-on and practical approach to learning about mathematics. At the same time, the SIG has chosen to refer to ourselves as the EC Mathematics SIG (rather than numeracy) for a number of reasons. We agree with the idea that 'while the development of numeracy is important, education and curricula at all levels, including preschool, should encompass a broader view of mathematics and of mathematics learning' (Dunphy, 2018, p. 106). As Wolfe (2015) points out, language is political tool used with intent. It is our intent in choosing this language to

1) Acknowledge that **children are capable** of understanding and applying mathematical ideas from a young age.
2) Highlight the **crucial role of the early years educator** in supporting the development of children's fundamental mathematics skills. This requires specific mathematical knowledge and skills on the part of the EC educator. These are mathematics skills that PLÉ should be supporting our members (and the students they teach) to develop.
3) To counter the notion that 'numeracy' in EC settings implies an informal, hands-off approach to children's mathematical learning. Some **intentionality on behalf of the educator is required**. This does not equate to formal teaching but instead requires a change in perspective on behalf of the adult and a willingness to adopt a maths lens in their everyday practice.
4) To **promote mathematics** as valuable and appropriate in EC. We argue that the breadth and depth of mathematics concepts that young children engage with and understand are often not acknowledged in ECE.

5) Counter **fear and anxiety** pertaining to Mathematics. To raise awareness of the variety of mathematics in children's play and routines that educators already support. Mathematics is not a bad word. We as educators learn about mathematics (a knowledge domain) so that we in turn can support children to apply that knowledge in play, interactions, and experiences in EC settings i.e. numeracy.
6) To **uncouple 'numeracy' and 'literacy'** in the minds of EC educators. These two ideas are often linked in policy documents (O'Neill, 2021 for further detail about this) providing those with maths anxiety or a lack of interest in mathematics an opportunity to focus on literacy to the detriment of numeracy.

For these reasons, the term *early childhood mathematics*, rather than numeracy, was adopted by the PLÉ SIG.

Conceptualizing Early Mathematics Event

On 1st May 2024 PLÉ members attended the 'conceptualising early mathematics' event in Dublin City University. 13 lecturers from 8 institutions across the ROI contributed their expertise to the days' events. The focus for the day was how EC mathematics is currently conceptualised and facilitated within EC degree programmes in ROI. More specifically, the event aimed to gather opinions pertaining to the appropriateness of mathematics in early childhood, the group's self-efficacy in supporting mathematics and exploring what mathematics content, if any, should be incorporated in EC degree programmes.

The event included a number of presentations and discussion sessions facilitated by PLÉ early mathematics SIG members. These included a research overview, world café sessions, presentations of EC math modules content and structure, and group discussions.

- **Research Overview**

  An overview of findings from a recent study carried out by the EC Mathematics SIG. This study found that there is little consistency in the amount or type of early mathematics content included in EC degree programmes in the Republic of Ireland. Respondents, all PLÉ members, reported a need for greater professional supports to enable them to teach EC mathematics on their programme. See O'Neill et al. (2024) for further details of this research.

- **World Café session**

  The world café sessions gathered participant perspectives pertaining to the following research questions: 1) How appropriate is Mathematics in early childhood? 2) What level of Mathematics self-efficacy do PLÉ members possess? 3) What mathematics content should be excluded from / included in EC degree programmes?

- **EC mathematics Undergraduate Module presentations.**

Lecturers from 3 universities outlined the current structure of their mathematics or numeracy module. This included the module title, learning outcomes, indicative content, structure (year of degree it is offered, whether it is a workshop or lecture, standalone or composite module). Modules discussed shared few similarities highlighting the lack of coherence across institutions

- **Discussion**

  Opportunities for reflection, discussion and analysis were provided throughout the day. These sessions focused on bringing together ideas and addressing next steps for the EC mathematics SIG and for PLÉ.

Method

The world café method is often used for public consultation or organisational change processes (Löhr et al., 2020) and was chosen for its *rigor, relevance* and *speed* (Schiele et al., 2022). The process facilitates informal conversation among groups regarding a particular problem or topic. Table 1 provides an overview of the method's characteristics.

Typical characteristics of the world café method include:
• 3 or more rounds of conversation- 20 to 30 minutes each • One question per table • Write, doodle or draw ideas • 4-5 travellers change tables after each round • One host stays to facilitate the discussion of the next group • Ideas are refined as the process progresses

Table 1. Characteristics of World Café Method

Designed to be as inclusionary as possible the word café enables an open but intimate discussion to gather the views and knowledge already present within a group of people (Löhr et al., 2020). Brown and Isaacs (2005) developed the world café method to include a number of key design principles. While some of these principles focus on the provision of a welcoming

space and establishing context, others more closely relate to consensus building. For example, everyone's contribution is encouraged, cross-pollination and connection of diverse perspectives is supported, and the identification of pattern, insight and further questions leading to the identification and sharing of collective findings and understanding is the ultimate goal (Brown & Isaacs, 2005).

Participants

Invites to the event were issued via PLÉ and 13 individuals from third level institutes participated. All participants were female and teaching mathematics or had an interest in teaching mathematics on an early childhood degree programme in a third level institute in the Republic of Ireland. While this is a limited sample in terms of gender, ethnicity and other characteristics, this is reflective of the current cohort of EC lecturers in ROI.

Data Collection

Table 2 provides an overview of data generated as part of the event. Examples of data generated include personal post-its, images/ drawings, discussion topics and online polls.

Method	Discussion frame	Data generated for analysis
3 x 25 minute world café rounds	1. How appropriate is Mathematics in early childhood? 2. What level of Mathematics self-efficacy do PLÉ members possess? 3. What mathematics content should be excluded from / included in EC degree programmes?	Summaries of discussion from each group in each round. Overall ideas in each round noted by nominated group member Personal post-its noting ideas, feedback and suggestions
Online polls	Identify priorities for PLE Maths SIG	Results from 2 x open-ended polls capturing reflections and ideas
Evaluation of event	Identify next steps for PLE Identify areas that require support	Hard copy evaluation during the event Follow up soft copy evaluation in the week after the event

Table 2. Overview of data generated at the reconceptualising Math event

Data Analysis

NVivo software was used to sort and categorise data from the various sources and carry out analysis. In initial stages of analysis, codes (and examples of these), were identified using a semantic approach. Once the data became more familiar a more reflexive thematic approach (Braun & Clarke, 2019) was adopted. In line with examples from Byrne (2022) this led to a series of sematic and latent codes being identified and some data being 'double-coded in accordance with the semantic meaning communicated by the respondent, and the latent meaning interpreted by the researcher' (p.1398).

Findings and Discussion

Three research questions framed discussions during the day; 1) how appropriate is mathematics in early childhood? 2) what level of mathematics self-efficacy do PLÉ members possess? and 3) what mathematics content should be excluded from / included in EC degree programmes? Findings will be discussed under these three headings.

1. How appropriate is Mathematics in early childhood?

Participants reported that mathematics is 'essential' 'very important' and 'appropriate from birth'. There was general agreement that mathematics is an important element of early childhood education, but that its conceptualisation differs considerably from mathematics education in the later stages of the education continuum. The focus in early childhood remains firmly on the use and application of mathematics in daily life, rather than a focus on formal learning or teaching of mathematics.

> *"Maths is part of everyday life. Children should not be excluded from any concept that is so significant."*

The need to include mathematics in ECEC, and therefore in EC degree programmes, was highlighted. Participants commented frequently on this point across the day and evidence was found within the various forms of data gathered. Similarly, the need to establish the usefulness and applicability of mathematics for young children was central to discussions. One participant commented that children are not being exposed to applied mathematics in the home in the same way that previous generations would have been due to the changes in lifestyle and the ubiquitousness of centre-based childcare. She explained

"Young children are not getting enough exposure to mathematics at home e.g. shopping, baking, DIY, nursery rhymes, judging distance. The onus is on EC educators to provide this."

It should be noted that there was a great deal of discussion and debate about the use of the term mathematics rather than numeracy. The group identified the need to distinguish between the two not only for students but also for lecturers. Many were not clear about this difference and suggested that a glossary of terms would be useful starting point as highlighted by the following comment:

'The need to start to use math terminology in early years rather than a broad sweep with 'numeracy' which is only a part of maths in early years'.

2. What level of Mathematics self-efficacy do PLÉ members possess?

In general, PLÉ members reported that they were competent in facilitating early mathematics modules for EC undergraduates. It was noted that many EC initial education programmes have very low level of mathematics, if any (O'Neill et al., 2023). As such, EC educators [and lecturers] don't always possess formal training in EC mathematics. A high number of participants in this cohort however (11/13) had a Montessori background, an approach to early childhood education that includes explicit mathematics content as part of the curriculum. One participant reflected on this fact and commented '*How many of us are Montessori trained? Is that why we are here?'* leading the group to question whether some forms of ECEC initial education leads to a greater interest and or self-efficacy in EC mathematics.

There was general consensus that specific mathematic knowledge *is* required by lecturers to support EC undergraduates' mathematical content knowledge and pedagogical content knowledge. This specific knowledge included a clear concept of what EC math entails and the

distinction between mathematics as a subject or knowledge area, and numeracy as it applies to everyday life. While ECE educators support numeracy, they must possess mathematical knowledge to notice, identify and encourage mathematical understanding.

Despite the fact that participants generally reported high levels of math self-efficacy, they also frequently mentioned maths anxiety, fear and low confidence. In some instances, the fear reported was that of EC students, but participants own uncertainty was also discussed at length. For example, the following are comments from the world café discussion pertaining to EC lecturers but could also easily be transferred to a student/ educator cohort:

> *"In literacy and numeracy modules we stick with literacy due to higher confidence here'*
>
> *"Confidence is fed by knowledge."*
>
> *"Fear is removed when math is made accessible and learnable".*
>
> *"Professional autonomy can lead to less maths in the classroom".*
>
> *"Efficacy depends on people's perceptions of what maths entails."*
>
> *"Maths anxiety is not so bad with 'numeracy' but is worse with 'mathematics'."*
>
> *"As my awareness of [maths] pedagogy has grown, I see how much mathematics I introduce in everyday activities'.*

In addition, lecturer's confidence in their own mathematics MCK and PCK, their ability to teach this to others, and some element of practical experience in supporting mathematics learning in EC were deemed important. Specifically, the group identified the need for appropriate, formal training of EC lecturers and EC educators to support understanding of 1) fundamental math content knowledge, 2) the use mathematical language and 3) applying mathematical concepts to everyday experiences, interactions, and routines. For examples, one participant reflected:

"unless the lecturer has maths knowledge passion and experience how can students be supported?"

Reflecting on mathematics as a new EC policy requirement it was agreed that math should be adopted like any other new or emerging practice or research focus.

'Why do we think we don't have to learn mathematics? We learn about every other EC theory old or new'.

3. What mathematics content should be excluded/ included in EC degree programmes?

There was strong consensus that directive, adult led, didactic or formal approaches to mathematics should be excluded from EC degree programmes. Despite this, there was enthusiasm for the *intentional inclusion* of mathematics in EC. Discussions centred around the provision of math that supported embodied cognition of mathematics, applied to children's play and routines, and exposed children to various forms of mathematics over time.

As well as more general discussion about how math should be supported, noted in the data was more specific reference to mathematical content knowledge (MCK) and mathematical pedagogical content knowledge (PCK). This included

- Maths content knowledge: geometry (2D and 3D shape), space, number operations, pattern, measure, data, and counting.
- Maths pedagogical knowledge: modelling mathematical language, using a math-lens, slow pedagogy, exposure to maths ideas in different ways over time to encourage concept development, use of learning trajectories as a framework or scaffold, learning goals rather than outcomes, no didactic or adult-led pedagogy, the need to position maths processes, such as problem solving, as part of mathematics.

Respect for child-centred and play traditions were prominent. Once again, contributions focused on math in naturally occurring situation and interactions, indoors and outdoors, in play and routines, in nature and incorporating maths into ECE without schoolification. Unsurprisingly active learning methodologies were considered more appropriate and multiple examples were discussed such as parking cars in the outside area (shape/ space), using playdough (2D and 3D shape), welcome songs and circle time (counting and number operations), getting dressed and going outdoors (sequencing and time) and the potential of picture books. The provision of practical experiences for pre-service students to alleviate fear and support enjoyment of maths, although less common, was also cited.

4. Other emerging themes

A number of other themes emerged in the data including 1) the varying amount of mathematics content on degree programmes, 2) the need for further PD supports and resources for EC lecturers, and 3) the continued focus on mathematics for young children to the detriment of babies and toddlers.

Having reviewed the content of a number of mathematics, numeracy or blended (for example literacy *and* numeracy module or a STEM module) modules currently offered on EC degree programmes there was agreement that the inclusion of a wider variety of math content was possible and desirable. At present, some programmes are confined by their programme structures, and it may take considerable time to adapt. However, leading on from the discussion about what content could be included and the impact of mathematics avoidance and anxiety, the limitations of current provision were noted:

> *'Listening to the range of maths concepts covered in a standalone maths module made me realise the limitation of a broader STEM module encompassing maths'*

A number of contributors reflected on the missed opportunities to support children or students' math learning due to their personal lack of content and/ or pedagogical knowledge and concluded that '*children are missing out'*. As such, there was general consensus that a more intentional and varied provision of EC mathematics is warranted in EC degree programmes in ROI.

A number of data sources suggested that EC lecturers require more support to streamline and consolidate their own MCK and PCK. This theme was prominent in the final soft and hard copy evaluation forms: *'There is a significant need for more knowledge about mathematics in early years'*. A number of actions were suggested to support understanding in EC mathematics and to provide central supports for lecturers. This included devising a glossary of mathematical terms (for example, embodied cognition, maths lens, cardinality, numeracy), the creation of a centralised online space where useful materials could be uploaded and shared, and the creation of a position paper to agree a framework of mathematics content suitable for EC to support programmatic review. There was agreement that some consistency across mathematics modules would be welcomed. One comment sums it up well stating "a more uniform approach needed across all universities in order for students to graduate with the same knowledge base".

Finally, the group identified a duty to support the fundamental math development of birth to 3-years age range in EC settings. This cohort was discussed very little during the day, but this omission was acknowledged in final discussions and identified in a number of evaluation forms. To support lecturers, an event focused solely on this age group was suggested by one participant. Other suggestions included carrying out research into mathematics for the birth to 3 year age range in ROI or carrying out a scientific literature review on this topic to be shared with the SIG and beyond.

Implications / Key messages

The following section provides an overview of findings based on the data gathered at the 'Conceptualising Early Mathematics' event on the 1st May.

1. **How appropriate is Mathematics in early childhood?** There is strong consensus that mathematics is appropriate in early childhood education. Participants reported that mathematics is 'essential' 'very important' and 'appropriate from birth'. There was general agreement that mathematics is an important element of early childhood education, but that its conceptualisation differs considerably from mathematics education in the later stages of the education continuum. The focus in early childhood remains firmly on the use and application of mathematics in daily life, rather than a focus on formal learning or teaching of mathematics.
2. **What level of Mathematics self-efficacy do PLÉ members possess?** Participants generally reported high levels of math self-efficacy. The group identified that specific mathematic knowledge *is* required by lecturers to support EC undergraduates' mathematical content knowledge and pedagogical content knowledge. This specific knowledge included a clear concept of what EC math entails and the distinction between mathematics as a subject or knowledge area, and numeracy as it applies to everyday life. While ECE educators support numeracy, they must possess mathematical knowledge to notice, identify and respond to the mathematics observed, either in the moment or plan enhancement. Despite the fact that participants generally reported high levels of math self-efficacy, they also frequently mentioned maths anxiety, fear and low confidence and participants identified further support that would be welcomed.
3. **What mathematics content should be excluded from / included in EC degree programmes?** There was strong consensus that directive, adult led, didactic or formal approaches to mathematics should be excluded from EC degree programmes. Despite this, there was enthusiasm for the *intentional inclusion* of mathematics in EC. Discussions

centred around the provision of math that supported embodied cognition of mathematics, applied to children's play and routines, and exposed children to a variety of mathematics topics.

The data recorded at this event suggests that mathematics is an important element of early childhood education and care. As such a number of key recommendations arose from the event, including next steps for the PLÉ early mathematics SIG, PLÉ and its members.

- EC mathematics should be given the same level of importance as literacy on EC graduate programmes. In order to achieve this, the visibility of mathematics on EC programmes and clarity about how this is conceptualised, is required.
- Specific knowledge, skills and pedagogy are required to support young children's fundamental math skills. Therefore, EC degree programme in ROI should include this mathematic content on their programmes.
- A distinction should be drawn between mathematics and numeracy. As educators we require a high level of mathematics knowledge (content and pedagogical) in order to notice, identify and support numeracy in EC settings.
- A standalone mathematics module on all EC degree programmes would be welcomed. The breadth and depth of math content that young children are capable of is unlikely to be covered within partial or blended modules such as STEM or *Literacy and Numeracy*.
- The group recommended that a greater focus on the birth to 3-years age range was required. This may include carrying out empirical research, scientific literature reviews or PD focused specifically on babies and toddlers.
- Lecturers require more support in relation to EC mathematics, as for many, this content was not included in their own pre-service education. Recommendations about provision of resources, communities of practice and information sharing systems were made and will be enacted.

Next Steps

The aim of the early Mathematics SIG is to support PLÉ members in their role as lecturers, undertake EC mathematics research, and influence policy decisions pertaining to EC mathematics. The SIG is considering plans to address the issues identified in this report and suggested actions are outlined below. Proposed actions will be shared with SIG members and the PLÉ committee in December 2024. Based on capacity of SIG members to undertake this work, a strategic plan will be developed and agreed for the 2024/25 and 2025/26 academic years.

Member Supports	In person and online events
	Glossary of math terms
	Centralised online space to share materials
	Mathematics Book club
	Provision of further PD using 'a back to basics' approach
Focus on Birth to 3	In person event
	Empirical research in ROI
	Scientific literature review/ Meta analysis
Guidance	Identify PCK, MCK and indicative content for EC degree programmes
	Working paper to support programmatic review
	Position paper outlining PLÉ's stance pertaining to EC mathematics

Table 3. PLÉ Early Mathematic SIG Proposed actions for 24-25 and 25-26 academic years.

Glossary

SIG	Special Interest Group
PLÉ	Irish Association of Academics in Early Childhood Education and Care in Higher Education
PCK	Pedagogical Content Knowledge (*How* to teach). Knowing how to support children's fundamental mathematics development through play, routine, interactions and daily activity both indoors and outdoors.
MCK	Mathematical Content Knowledge (*What* to teach). Know what mathematical content children can learn in their early years for example: sorting and classification, number sense, measure, shape and space.
Numeracy	Numeracy refers to the way in which mathematics is used in everyday life and emphasises a hands-on and practical approach to learning about mathematics
Early Mathematics	The content knowledge required to support children's understanding of numeracy
Mathematising	Using a maths-lens to find the maths in everyday life
Maths Anxiety	A negative emotional reaction to mathematics which leads to varying degrees of panic and mental disorganisation
Maths Avoidance	Avoidance of maths related activities often linked to math anxiety
Self-Efficacy	One's belief in your ability to execute specific behaviours

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