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Supporting Literacy and Numeracy in Early Childhood for those at Risk of Educational Inequality

A Review of the Literature

Prepared by Geraldine French, Institute of Education, Dublin City University, for the Department of Education

Author Note

Geraldine French https://orcid.org/0000-0002-7075-038x

Suggested Citation

Summary: Supporting Literacy and Numeracy for those at Risk in Early Childhood

This literature review synthesises the literature on supporting children at risk of educational inequality in developing literacy (digital literacy) and numeracy in early childhood education and care (ECEC).

- In the context of vocabulary learning and shared book reading knowing the meaning of words (vocabulary knowledge) is predictive of future reading comprehension (Christ &Wang, 2011). Providing explicit information about words being taught *and* giving children opportunities to engage in word learning in the context of storybook reading or other meaningful activities may be the most effective approach for enhancing word knowledge and word meanings for young children at risk of educational inequality (Marulis & Neumann, 2013). Reading development starts before children are formally taught to read (Mol & Bus, 2011). The main approaches to enhance vocabulary learning include: purposively exposing children to print (Mol & Bus, 2011) and advanced words; directly teaching children the meanings of words through labelling, recasting, questioning and employing multiple methods (Christ &Wang, 2011), or comprehensive approaches, which include phonemic awareness and other skills along with child-initiated activities (Chambers, 2016). Book-sharing and dialogic reading are essential (Dowdall et al., 2020). Research emphasises the critical role of adult-child interaction during book reading for vocabulary learning (Wasik et al., 2016).

- Six-month-old babies are capable of making marks in their yoghurt on their high chair trays. From two years of age children create, express, imagine, and test hypotheses and understanding about their world through making marks on a page or a digital tablet (Neuman, 2022). Enhancing the quality of the environments and adult engagement within the context of authentic early writing experiences (Hall et al., 2015) and invented spelling facilitates young children's early literacy development (Ouellette & Sénéchal, 2017; Albuquerque & Alves Martins, 2019).

- Joo et al. (2020) examined the impact of adding ECEC enhancement programmes to existing programmes. The addition of fully developed parent programme and skill-based curricula to ECEC programmes can result in improvements to a range of children's outcomes. Parents who talk more with their children also tend to use more of the rich vocabulary, complex ideas, and back-and forth conversation known to promote language growth. Furthermore, adding skill-based curricula to ECEC programmes, especially literacy/language-specific curricula, results in improvements to children's cognitive abilities, pre-academic skills, and overall outcomes (Ciesielski & Creaghead, 2020; Joo et al., 2020; Markussen-Brown et al., 2017).

- Culturally informed approaches are necessary and include culturally relevant teaching, culturally responsive teaching, culturally sustaining pedagogies. Such approaches are rooted in multicultural education, where the focus on equity marks a departure from the classification of culturally diverse students as having a cultural deficit (Kelly et al., 2021). Positive effects were found for all language promoting interventions that were both

linguistically-and culturally-responsive (Larson et al., 2020). Interventions deemed linguistically responsive intentionally support use of children's home language. Culturally informed literacy instruction is an orientation and not a set of activities. However, a repertoire of approaches can be developed; e.g., developing reading passages by listening to children describe their daily experiences (Cartledge et al., 2015).

- A meta-analysis on multi-tiered systems of support (MTSS) for language, literacy and numeracy in early childhood was conducted (Shepley & Grisham-Brown, 2019). Tier 1 involves general education; 2 targeted interventions usually in small groups, and 3 individualised supports. Compared to interventions with older school-going children, there are particular challenges in implementing approaches targeted at younger children (e.g., diversity of settings, funding streams, curricula and interventions) leading to a lack of implementation fidelity. ECEC favours child-initiated, play-based approaches, which are at variance with teacher–led approaches. Statistically significant findings are evident for literacy and social–emotional outcomes. However, due to the heterogeneity of research findings, caution was expressed in providing guidance on system-wide MTSS models in ECEC (Shepley & Grisham-Brown, 2019).

- A systematic review focussed on interventions targeting students with or at risk of academic difficulties in literacy and mathematics and gave unambiguous positive results, from the perspective of publicly funded scaled up interventions (DeAngelis et al. 2018). Some of the common themes in the projects include staff qualifications in ECEC, maximum class size of 20 children with a minimum of two adults, and a preference for children at risk of educational inequality while including all children.

- Despite compelling evidence that children "do engage in mathematics education prior to four years of age, and that they possess many mathematical competencies", there is a dearth of reviews which focus on children from birth to four years (MacDonald & Murphy, 2021, p.522). Nonetheless some key findings are worthy of consideration. In terms of selecting early numeracy interventions, children "who do not develop early numeracy skills are likely to have difficulty with achievement in math in later" years (Nelson & McMaster 2019, p. 194). Early numeracy, which features a set of foundational skills in understanding whole numbers (such as quantity, counting, comparison) contains the building blocks to learning more complex skills such as addition and subtraction. The research emerging from the USA is comprehensive and robust but not necessarily directly relevant to Ireland. Given our different cultural context and policy development, it is therefore very important that we also develop more research-based evidence here.

- Predictors of successful transition to school include exposure to high quality ECEC, experience of mathematical and literacy-based tasks, warm parenting style, supportive home environment, learning related to personal child characteristics, social behaviour, and health and socio-economic status (Linder et al., 2013). Some studies are rooted in the concept of 'school readiness' (DeAngelis et al., 2018, Joo et al., 2020; Linder et al., 2013). Bingham and Whitbread (2018, p. 364) argue that the 'schoolifying' of the ECEC

years i.e. before compulsory school age "is not supported by the research evidence and that it is very likely to be damaging, particularly for the most deprived and youngest children". The real issue is determining how to meet the children's socio-emotional needs in a smooth transition to school and consistency in teaching methodologies that include a play-based curriculum (physical, constructional and social play), child-initiated experiences and responsive interactions in ECEC settings and primary school.

- Play can promote learning in a range of academic domains and can close achievement gaps for children ages 3 to 6 years. However, play "is not taken seriously as an inclusive solution to the development of children's knowledge and holistic skills…More often, play is seen as something separate from the seriousness of school and work" (Dowd & Thomsen. 2021, p.8). As the natural mode of learning for children, play is *imperative* as a strategy for enhancing young children's learning.

Recommendations

Children's vocabulary learning, oral language development and shared book reading

To narrow the achievement gap, create interventions powerful enough to accelerate children's vocabulary development (Marulis & Neumann, 2013). Educators could provide explicit information about words being taught *and* give children opportunities to engage in word learning in the context of storybooks (Christ &Wang, 2011). Theme based strategies for vocabulary instruction; a variety of vocabulary teaching methods; multiple instances of exposure for each word; pedagogical methods that allow children to acquire a depth of word knowledge that meets their need for understanding meaning, labelling, read-aloud-based interventions, and play with target words are recommended (Christ &Wang, 2011). Educators could provide child-initiated activities, activity stations, art, music and play in small groups or dedicated whole class time (Chambers et al., 2016). Furthermore, parents and educators should engage in shared dialogic book reading (Wasik et al., 2016) and "start a reading routine early in children's development" to familiarise children with books and reading material generally (Mol & Bus, 2011, p.287). Further research incorporating longitudinal studies for children at risk is recommended (Dowdall, 2020). (*Pillar 1: Enabling Parents & Communities; Pillar 2 ECEC educators professional practice; Pillar 4: Curriculum*)

Mark making/emergent writing and invented spelling

Design play spaces with literacy objects that "can stimulate and encourage children to participate in meaningful literacy behaviours" with educators engaged in writing experiences through modelling and guidance, journaling, bookmaking, interactive writing, shared writing (Hall et al., 2015, p.23) and invented spelling (Ouellette & Sénéchal, 2017; Albuquerque & Alves Martins, 2019). (*Pillar2:ECEC educators' professional practice; Pillar 4: Curriculum)*

Adding enhancements to existing ECEC programmes

It is recommended to add comprehensive parent programmes, in particular building positive parent-child relationships and exposure to reading materials in the home environment (Linder et al., 2013). Additional educator professional development enhancements (Ciesielski & Creaghead, 2020; Markussen-Brown et al., 2017) to include content-rich skill-based curricula in language, literacy and mathematics to ECEC programmes which are appropriate to the context of children's development and include play and fun experiences to influence young children's later achievement is recommended (Joo et al., 2018). When these enhancements are well-developed and geared toward developing specific skills, ECEC programmes can have a substantial impact on a range of children's ECEC outcomes. (*Pillar 1: Enabling Parents & Communities; Pillar 2 ECEC educators' professional practice; Pillar 4: Curriculum)*

Culturally informed approaches in practice and research

Attention to "what makes instruction culturally informed" is advised by gaining full knowledge of students/children before judging what is responsive to them; *not* considering a choice of texts featuring people of the same background as culturally informed – whilst

acknowledging that as a potential starting point to culturally informed literacy instruction (Kelly et al., 2021, p.93). Larson et al. (2020) recommend for culturally and linguistically diverse children attending ECEC programmes, "improving access to high quality early care and education should be a high priority of policymakers" (Larson et al., 2020, p.175). However, such ECEC must provide cultural or linguistic adaptations to significantly affect language outcomes in the home language or English. Support for children's home languages is not only important for children's cultural identity and family ties but can also lead to long-term academic gains (Arellano et al., 2018) (*Pillar 1: Enabling Parents & Communities; Pillar 4: Curriculum; Pillar 5: Students with additional learning needs*)

Multi-tiered systems of support for language, literacy and numeracy

Whilst statistically significant findings are evident for literacy and social–emotional outcomes, due to the heterogeneity of research findings and other limitations, caution was expressed in providing guidance on system-wide MTSS models in ECEC. "More rigorous research is needed with a focus on interventions and practices that are established and align with the delays of individuals needing tiered services based on a formal assessment process" (Shepley & Grisham- Brown, 2019, p.307). (*Pillar 6: Assessment and evaluation*)

Impact of scaled up and tutoring interventions on numeracy and literacy

DeAngelis et al., (2018) recommend that access to quality ECEC should be offered based on the importance of intellectual stimulation for very young children and on the positive short-term effects of pre-Kindergargen programmes and should be combined with rigorous longitudinal experimental research to determine the long-term impacts of programmes in the future (DeAngelis et al., 2018). (*Pillar 2: Teachers and ECEC educators' professional practice; Pillar 4: Curriculum*)

What to consider when selecting numeracy interventions in early childhood

Reviews in the context of the USA highlight the effectiveness of using multiple representations (pictures, talk, symbols) to teach math content, especially with students with a math disability (e.g., Jitendra et al., 2016), explicit and systematic instruction and computer-assisted instruction (e.g., Mononen et al., 2015). Note only four of the 20 studies focussed on ECEC (from age three years). More investigation into how math vocabulary is taught and integrated into early numeracy programmes is warranted; more pointed information to support students from linguistically diverse backgrounds is needed. Educators are advised to consult with school-based experts and "have resources to investigate studies, intervention reports, and reviews of interventions to make the best decisions for their students" (Nelson & McMaster, 2019, p.205). (*Pillar 4: Curriculum; Pillar 5: Students with additional learning needs*)

Predictors of successful transition to school and the importance of play

Children need exposure to high quality ECEC (to include child-initiated experiences and responsive interactions; a play-based curriculum, experience of mathematical and literacy-based tasks, warm parenting style, and home environment (Linder et al., 2013). The role of learning through play needs to be elevated to counteract inequality in children's outcomes and opportunities and should be an integral part of any government policy aimed at giving children greater skills and knowledge in their early years (Dowd & Thomsen 2021). Four areas for future investment, investigation and innovation are recommended. 1. Documentation of facilitated guided and free play in poorly resourced contexts. 2. Testing 'disruptive' interventions ('disruptive' due to the professional development and behaviour change required of educators) which promote child choice, free and guided play, pretend play, and 'incremental' interventions which focus on the addition of some of these approaches to educator-directed play schemes. 3. Studying early childhood interventions through an applied playful lens. 4. Delivering longitudinal studies of play in early childhood (Dowd & Thomsen 2021). (*Pillar 1: Enabling Parents & Communities; Pillar 4: Curriculum*)

Introduction

Studies demonstrate that for young children, particularly those who face adversity, poverty and educational inequality, high quality Early Childhood Education and Care (ECEC) can lead to better school achievement, higher cognitive test scores, fewer special education placements and higher school retention rates (Organisation for Economic Cooperation and Development, 2018; Taggart et al., 2015). In particular, the language input that children receive from their families at home and educators in early childhood settings matters (Larson et al., 2020). The oral language skills of a two-year old child predict literacy and broader outcomes at school entry (Morgan et al., 2015), which in turn predict later school achievement (Duncan et al., 2007). Equally, exposure to concepts of early numeracy (e.g. quantity discrimination and counting) predicts written computation at age seven (Desoete et al., 2012). Children must also understand and apply vocabulary in mathematics (Nelson & McMaster, 2019). Therefore, attending to strengthening the resources and capabilities of the families and educators who care for them is important. In Ireland, according to our national frameworks, early childhood education is from birth to six years. In the systematic reviews that underpin this paper 15 focussed on children from three years; while only three reviews focussed on children from birth implying a significant gap in the research. This review responds to the research questions below.

> **Research questions**
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> 1. What strategies support children from birth to six years, at risk of educational inequality in developing literacy, including digital literacy?
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> 2. What strategies support children from birth to six years, at risk of educational inequality in developing numeracy?

The following themes emerged from the systematic reviews (see the Appendix for the research strategy and tabulation of results) and are presented as follows. Children's vocabulary learning and oral language development; shared book reading; mark-making /emergent writing and invented spelling; adding enhancement programmes to existing ECEC; culturally informed approaches; multi-tiered systems of support; impact of scaled up interventions on numeracy and literacy; selecting numeracy interventions and finally the predictors of successful transition to formal schooling and the importance of play. Many of these studies were conducted in the United States of America (USA); therefore, caution should be exercised when making comparisons directly to the Irish context.

Children's vocabulary learning and oral language development

By three years of age, there is a quantitative and, by proxy, qualitative word gap between high socio-economic status (SES) children who knew more than 600 words on average than their low SES counterparts at age three (Hart & Risley, 1995). Despite criticism of Hart and Risley's original study (Fernald & Weisleder, 2015), studies with larger samples of families from more diverse backgrounds, confirm that disparities remain among children in their early language experience and are related to several different aspects of vocabulary and language growth (Hoff, 2013; Song et al., 2014). Research has demonstrated that by 24 months of age, English-learning children from lower-SES families were already 6 months behind their more advantaged peers in vocabulary and language understanding (Fernald et al., 2013). This "word gap is shown to widen as the child gets older" pointing to the importance of prevention and early intervention (Oxford Primary, 2018, p.6). The quality of adult-child communication interactions is as important as the quantity of words that children are exposed to. High quality interactions using a variety of vocabulary located in the child's area of interests and using the vocabulary in different contexts is advised (Oxford Primary, 2018). Centring the curriculum on talk, using nursery rhymes and traditional tales and ensuring that educators have professional development to model language and conversation give children a stronger grasp of language by the time they start school (Oxford Education Language Group, 2022).

A meta-analytic review by Marulis and Neuman (2013) examined how word-learning interventions affect young children (pre-kindergarten and kindergarten in the USA) who are at risk for reading difficulties, on vocabulary outcomes, which might in turn, impact on their reading achievement. The researchers reviewed 51 studies with 138 effect sizes ($N = 7,403$). Using a random-effects model, they reported a mean effect size of 0.87 standard deviations indicating a strong training effect overall on vocabulary. However, effect sizes varied from –0.10 to 2.13. Children from low-socioeconomic-status (SES) families experienced significantly lower word-learning gains than those from middle- and upper-SES families who had one or more risk factors (e.g., English language learner, language delays). This was true regardless of the total number of risk factors present. However, risk factors *in addition to poverty* did compound this SES disadvantage (i.e. intervention effects continued to decrease for children living in poverty with additional risk factors). Subgroup moderator analyses indicated a number of instructional and pedagogical factors. Frequency, duration and intensity of interventions were not associated with effect sizes. Group size (individual, small groups of 5 or less, larger groups of 6 or more, and combinations of small and large

groups) was not associated with effect sizes, but the person delivering the instruction was, with stronger effects for qualified educators, researchers, and parents, compared with unqualified child-care workers. Interventions with combined (explicit and implicit) word learning instruction targeted to individual words were significantly more effective than interventions based on implicit instruction alone, while comparisons between explicit and implicit instruction, and explicit and combined instruction were not significant. Marulis and Neumann interpreted this as indicating that providing explicit information about words being taught *and* giving children opportunities to engage in word learning in the context of storybook reading or other meaningful activities may be the most effective approach for enhancing word knowledge and word meanings for at-risk young children. They also noted the importance of creating interventions powerful enough to accelerate children's vocabulary development in order to narrow the reading achievement gap. However, a couple of caveats also arise from this research: The mean scores on standardised pre-tests in studies in the review were very low (Mean = 79.9 on receptive vocabulary, 82.8 in expressive vocabulary). Hence, while the interventions for those at risk of educational inequality made a difference to children's learning of words, such differences may not have been substantive enough to bridge identified gaps. Most studies did not assess retention of vocabulary beyond their conclusion, meaning that the long-term effects of the interventions are not clear. The mean effect for low SES students in the studies was 0.79. Given their initial low base, this may be insufficient to overcome gaps with middle- and high-SES students. The lack of specification in the interventions (many were not tailored to the needs of recipient children) could explain why group size was not associated with effect sizes.

31 studies were systematically reviewed in the context of children at risk for educational inequality and three main approaches used in early childhood classrooms to support children's vocabulary learning were identified (Christ & Wang, 2011).

1. Purposively exposing children to advanced words (through reading stories, focussed video viewing and teachers' everyday speech in naturally occurring conversations).
2. Directly teaching children the meanings of words through labelling, recasting (replacing target words with a synonym in a repeated sentence), questioning, embedded instruction (defining the word in context) and extended instruction (attending to analytic, interactive, and sometimes phonological or phonic aspects of a word).

3. Employing multiple methods interventions/activities. The studies were divided into those that provide opportunities to review or produce vocabulary through theme-based interventions where vocabulary is selected based on an instructional theme (a finding later revealed by Chambers et al., 2016) or read-aloud-based experiences where vocabulary is selected from books.

The theme-based interventions can involve meaningful everyday events in homes and classrooms and concepts such as light and colour and are supported by prop-boxes for each theme that include objects representing target words, theme-based centres, and big book/little book readings. Read-aloud-based interventions involve researchers choosing target words from storybook (instructional approach). Typically, the teacher introduces the target word during first reading, reinforces words during subsequent readings and children practice the words in a variety of learning experiences (Nelson, 2008). Others used specific practices to support acquisition of vocabulary e.g. labelling props, presenting a print representation of an unknown word against the representation of two familiar words, didactic interactional reading with embedded definition instruction, play centres where the target words could be used and children indicating when they heard a target word (Schwanenflugel et al., 2005). The kind of target-word instruction and the frequency of target-word repetition mediate word-learning outcomes across these studies. Multimethod interventions seem to be most promising, due to an increase in children's general word knowledge, as measured by standardized tests. A focus on assessing *how* these interventions impact children's word-learning ability and long-term trajectories is more pertinent than the simplistic idea of whether practices are closing the word gap at a given point in time (Christ & Wang, 2015).

Mol and Bus (2011) in their meta-analyses revealed that in the group of 2- to 6-year-old children, print exposure is related, at moderate strength, with both oral language and basic reading skills. Exposure to storybooks explained about ten to twelve per cent of young children's language and eight per cent of children's basic reading skills in each investigation. Their findings reveal that "that reading development starts before formal instruction, with book sharing as one of the facets of a stimulating home literacy environment" (Mol & Bus, 2011, p.288). A key recommendation is that from very early on in a child's development, parents, carers and educators should familiarise children with books and reading materials generally, and establish a reading routine. The meta-analyses suggest that reading routines,

which are part of the child's leisure time activities, offer substantial advantages for oral language growth, reading comprehension and technical reading skills (Mol & Bus, 2011).

Shared book reading

Wasik et al. (2016) reviewed studies systematically which focused on book reading practices in early childhood that have resulted in increases in early vocabulary. Dowdall et al. (2020) undertook a meta-analysis on the efficacy of shared picture book reading using randomised control trialled interventions for child language development. Although the effects of interventions are modest - children were not learning all of the words that they were taught (Wasik et al., 2016) or had a small sized effect on both expressive language ($d = 0.41$) and receptive language ($d = 0.26$) (Dowdall et al., 2020), some key take away messages emerged. Adult child interaction during book reading is critical for vocabulary learning to occur; the words that were learned were maintained over time. The number of words targeted may be one of the most important variables to understand more fully, because identifying an optimal number, or range, that supports child learning would inform helpful guidance for teachers and parents (Wasik et al., 2016). Note that Beck et al. (2008) have recommended four to six words a week for intensive instruction for children of five to six years of age. Furthermore, the higher the intervention dosage (i.e. duration and intensity), the higher the impact (Dowdall et al., 2020).

Five implications for classroom practice were identified (Christ & Wang, 2015). Educators could provide: (a) theme based strategies for vocabulary instruction; (b) multiple instances of exposure and instruction for each word; (c) pedagogical methods that will allow children to acquire a depth of word knowledge that is commensurate to their need for understanding the word's meaning; (d) assessment of children's incremental changes in word knowledge to identify growth and inform further instruction; and finally (e) a variety of vocabulary teaching methods (Christ & Wang, 2015). Teaching methods were addressed by Wasik et al. (2016) who offered six strategies—reading and re-reading texts, explicitly defining words, encouraging dialogue about book-related vocabulary through questions and discussion, re-telling, using props, and engaging children in post-reading, follow-up experiences. While these methods are consistently implemented across the studies, they are used in widely varying combinations, including the criteria for selection of words, the number of target words taught (from two to 20 per book), assessment measures and the

proportions of words learned. Questions remain on how to optimise vocabulary learning through book reading (Wasik et al., 2016).

Nonetheless, these results confirm the promise of book-sharing interventions, across a range of settings and modalities, for enhancing young children's language development, at least in the short term. Book-sharing or dialogic reading is distinguished from simply reading a book to children by the dialogic/interactive quality of the experience and use of pointing and labelling based on child's focus of interest, open-ended questions, encouragement for child participation and decontextualized talk that extend beyond the content of the book to new and novel concepts. Indeed, the authors argue that "book-sharing should be considered for any programme that seeks to support early literacy and language development in infants and young children" (Dowdall et al., 2020, p.396). Of interest is that book-sharing interventions can be equally effective regardless of the educational level of the caregiver. Furthermore, young and older preschool children benefit equally from these interventions and there is tentative evidence that group-based interventions are more effective than one-on-one interventions (validated by Chambers et al., 2016). Professional development interventions involving multiple sessions, with extended contact time between the instructor and caregiver, are highly likely to result in improvements to child language (Dowdall et al., 2020).

The importance of providing multi-method and comprehensive programmes was echoed by Chambers et al. (2016) in their systematic review. They found that in areas marked by high poverty and educational inequality, programmes that have had high success rates for increasing the language (productive and receptive language) and literacy (phonemic awareness, alphabet knowledge, phonics, concepts of print) were comprehensive in nature. The effect sizes averaged +0.15 for literacy and 0.08 for language outcomes and were maintained at +0.06 for literacy at kindergarten, and +0.06 for language. The programmes featured direct instruction with dialogic reading, child-initiated activities, activity stations, art, music and play. Explicit instruction takes place predominantly in small groups or whole class with dedicated time. The evidence in this review supports the inclusion of direct instruction on language and literacy in early childhood, dialogic reading and the prominent role of the adult.

Christ and Wang (2016), Dowdall et al. (2020) and Wasik et al. (2020) suggested that "more fine-grained analysis of book reading would help provide guidance to parents and

teachers who want to know what, specifically, to do with children in order to increase vocabulary learning" (Wasik at al., 2016, p. 55). Dowdall et al. (2020) recommended addressing the following research issues: measures of implementation fidelity of parents' and educators' application of interactive strategies to be included in studies; longitudinal studies to be undertaken to assess the durability of interventions; and comparison studies on group-based versus one-on-one interventions to be conducted. Finally, it was recommended to undertake research targeting children with language deficits or children at risk of failing to meet their developmental potential.

Mark making/emergent writing and invented spelling

Six-month-old babies are capable of making marks in their yoghurt on their high chair trays. From two years of age children create, express, imagine, and test hypotheses and understanding about their world through making marks on a page or a digital tablet (Neuman, 2022). Through mark making, young children are learning how to form representations using marks as tools to promote and consolidate their own meaning making (Brierley, 2018, p.145). Mark making stimulates active learning and innovation as children learn through physical (e.g., fine motor movement and coordination of fingers and hands), cognitive (e.g., thinking, reasoning, and problem solving), and social experiences (Hall 2019). The provision of mark-making materials as part of a print rich environment is essential.

Hall et al. (2015, p.8) in their systematic review of the impact of writing instruction on literacy skills defined early writing skills as "students' familiarity with writing implements, recognition of writing as a way of communicating for a variety of purposes, and use of scribbles, shapes, pictures, or letters to represent attitudes and ideas" (Halle et al., 2012; U.S. Department of Health and Human Services, 2010). The authors identify three philosophical approaches to writing instruction and adopted these approaches to categorise the studies in their review. 1) The maturationists provide a literacy rich environment with writing materials which children freely use in natural play settings with observation by the educator (e.g., Gessell). In this view children learn naturally in a predictable sequence i.e. handwriting and spelling first, then idea generation. 2) The constructivists/interactionists equally provide the environment with the addition of co-construction of knowledge in meaningful interactions with educators and peers (e.g., Dewey & Vygotsky). Children do not learn in a linear progression but simultaneously. Book making, interactive mark making are guided by the educator and influenced by peers. 3) The environmentalist/ behaviourists

provide educator directed learning activities with little relational learning (e.g., Skinner). "Systematic skill-based writing instruction focuses on teaching children how and when to apply specific writing skills to writing experiences directed by the teacher" (Hall et al., 2015, p.7). Here, children learn through the transmission of knowledge by the adult.

There was only one study found within a maturationist intervention. The focus was to examine the impact of physical design changes that introduced literacy related materials in the children's natural environment, on their spontaneous free play without adult involvement (Neuman & Roskos, 1992). Pre- and post-control groups were developed. The results revealed statistically significant differences in children's handling of materials, writing, and reading behaviours indicating that children were more likely to engage in complex literacy related play and for a longer period in a literacy rich environment. For example, children wrote, addressed, and posted letters in the intervention group compared to less authentic tasks such identifying letters on available print in the room in the control group. This study produced a large effect size ($g = .94$). The implications are to design play spaces with literacy objects that "can stimulate and encourage children to participate in meaningful literacy behaviours" (Hall et al., 2015, p.23).

Eight studies, that fall into constructivist/interactionist writing strategies, were found that extended the advantages of a literacy rich environment with the involvement of adults. They focussed on adult engagement (modelling and guidance), journaling (children explain what they have drawn in their journal and the teacher transcribes their words onto their page), bookmaking (children were supported to use their home language, technology, and personal photographs to create meaningful books to be shared with peers and families), interactive writing (children and teachers decide on a meaningful topic and co-construct the narrative and share the pen to write text, and later read the text together as a group), and shared writing (e.g., writing the morning message together). One study (DeBaryshe & Gorecki, 2007) investigated constructivist writing strategies within a comprehensive early literacy curriculum (see Chambers 2016, above). Along with adult-child conversations, dialogic reading, and phonemic awareness experiences, the intervention included shared writing, interactive writing, journaling, and bookmaking. Significant differences were found for phonemic awareness ($p = .003$), emergent reading ($p = .004$), and emergent writing skills consisting of both name and word writing skills ($p = .001$). Overall, these studies produce medium to large effect sizes ($g = .07 - 1.44$). The implications are that enhancing the quality of the

environments and adult engagement within the context of authentic writing activities facilitate young children's early literacy development.

Nine studies explored the effects of systematic and/or teacher-directed writing instruction on children writing skills. The environmentalist/ behaviourists interventions included name writing interventions (e.g., children traced their names or write the name of the popular culture character as demonstrated by the teacher); letter writing interventions where the teacher used a magnetic board to model writing letters while using directional language, following the teacher demonstration, the children were asked to write the letter in the sky and then in their personal blank writing book (e.g., Newmann et al., 2013). The majority of these showed a small to medium effect size and focused on increasing children's abilities related to specific early literacy skills (e.g., alphabet knowledge, print concepts, fine motor skills) rather than general literacy behaviours (e.g., book handling, scribbles, pretend reading) examined in many of the constructivist/interactionist studies. However, the authors report that the positive "results must be interpreted with caution due to the limited role of writing in the multifaceted interventions", the paucity of studies on handwriting, and the variety of dependent variables (Hall et al., 2015, p.21). They found it "problematic to issue sound conclusions with regard to the impact of instructional strategies for teaching writing related to students' early literacy outcomes" (p.25). The authors concluded that regardless of the philosophical approach, the effectiveness of writing instruction on children's emergent literacy outcomes was found to be relatively large in 11 out of 22 intervention conditions (Hall et al., 2015).

Research has demonstrated that the sophistication of young children's invented spelling experiences in kindergarten enhances children's literacy learning process and later outcomes (Ouellette & Sénéchal, 2017; Albuquerque & Alves Martins, 2019). 'Invented spelling' is defined as a child's self-directed and often spontaneous attempts to represent words in print and as a result is developmentally appropriate as it falls naturally within a child's zone of proximal development (Vygotsky, 1962, cited in Ouellette Sénéchal, 2017). Children are not required to reproduce a spelling or memorise spellings that are beyond their current level of development but are developing the spelling of words "that reflects, and potentially increases, their current knowledge" (p.86). Young children, with an average age of five and half years, were tested on multiple literacy measures (Ouellette and Sénéchal (2017). The measures included oral vocabulary, alphabetic knowledge, phonological

awareness, word reading, and invented spelling. The children were tested after one year, when they were in Grade 1, on spelling and reading. The authors demonstrated that invented spelling contributed simultaneously to reading, alphabetic knowledge, and phonological awareness. The implications are that "kindergarten children gain the opportunity to analyse the phonological and orthographic structure of words and may benefit from this knowledge to develop their future reading and writing skills" (Albuquerque & Alves Martins, 2019, p.20).

Adding enhancements to existing ECEC programmes

Joo et al. (2020) used data from a comprehensive meta-analytic database of ECEC programme evaluations published between 1960 and 2007 in the USA to systematically examine the impact of including extra and differing components within ECEC programmes, on children's learning outcomes. Their findings suggest that several approaches to improving the impact of ECEC can be effective. The addition of fully developed parent programme enhancements and skill-based curricula in language, literacy or mathematics to ECEC programmes can result in improvements to a range of children's ECEC outcomes leading to better school readiness (see below for comment on this term).

Fully developed parent programmes directly centre on developing parent's behaviour or their children's specific skills. The impacts included significant progress to children's health, behaviour, some elements of social and emotional outcomes and modest development to cognition and overall outcomes. There was no relationship with pre-academic skills, e.g., letter recognition, numeracy (other than conservation of number), suggesting that they were acquired in the classroom with educators (Joo et al., 2018). Similar to Mol and Bus (2011), Linder et al. (2013) report that interventions focusing on building positive parent-child relationships and enhancing aspects of the home environment have the potential to influence young children's later achievement.

The authors found that adding skill-based curricula to ECEC programmes, especially literacy/language-specific curricula, can result in improvements to children's cognitive abilities, pre-academic skills, and overall outcomes (Joo et al., 2018). Math specific curricula results in improvements in children's pre-academic skills and overall outcomes but not cognitive abilities. Joo et al's. (2018) study suggests that educators and policy makers move to implement academically content-rich skill-based curricula focused on promoting specific skills compared to widely used "global" curricula, while rightly cautioning the avoidance of

"didactic teacher developmentally inappropriate instruction" (p.15). Instead well designed curricula that are appropriate to the context of children's development include play and fun experiences are beneficial for children's early learning and development.

A further enhancement to ECEC is the professional learning and development of early childhood educators. The impact of professional learning and development of early childhood educators on children's phonological awareness was reviewed systematically with positive effects (Ciesielski & Creaghead, 2020). Some common features of successful professional learning and development were identified adapting to the education and experience of the educators; provision of explicit and scripted instruction in the content area and embedding in the existing curriculum with multiple professional learning and development components (Ciesielski & Creaghead, 2020; Markussen-Brown et al., 2017). Professional learning and development for educators supporting children who are additional language learners is critical as in Ireland 69% of ECEC settings reported having at least one child for whom neither English nor Irish is a first language (Pobal, 2021), which brings us to the importance of culturally informed approaches.

Culturally Informed Literacy Practice and Research

Culturally informed approaches take many guises (culturally relevant teaching, culturally responsive teaching, culturally sustaining pedagogies) and are rooted in multicultural education, where the focus on equity marked a significant departure from the classification of culturally diverse students as having a cultural deficit (Banks, 2013 cited in Kelly et al., 2021). Ladson-Billings (1995) theorized culturally relevant teaching to affirm student cultural identity and enable students to critically examine society to promote and enact social change. Gay (2002) theorized culturally responsive teaching in relation to curriculum content being authentically representative of students' cultures and experiences. Paris (2012) promoted culturally sustaining pedagogies which has as its goal multiculturalism and multilingualism. These culturally informed practices highlight assets-based approaches, draw from the experiences of students and their funds of knowledge and encourage critical consciousness and social transformation.

Researchers most commonly claim to document culturally relevant or responsive instruction (Kelly et al., 2021). However, in some cases they conflated the terms and related theorists. As result Kelly et al. (2021, p.93) call for "thoughtful selection of terms with

supporting citations and descriptive documentation of what makes instruction culturally informed". Recommendations for teacher educators and teachers arising from this study include: gaining full knowledge of students before judging what is responsive to them; *not* considering a choice of texts featuring people of the same background as culturally informed – whilst acknowledging that doing so can be a starting point to culturally informed literacy instruction; teachers enabling young children to develop their critical consciousness and therefore work toward social transformation (Kelly et al., 2021). Culturally informed literacy instruction is an orientation and not a set of activities. However, a repertoire of approaches can be developed. For example, in one study, Cartledge et al. (2015) developed reading passages by listening to children describe their daily experiences. In another study Christianakis (2011) developed students' critical consciousness through analysis of rap sessions and discussions of oppression.

The theme of culturally-responsive interventions was further addressed by Larson., et al. (2020). Their synthesis on interventions for improving language outcomes for young, culturally and linguistically diverse (CLD) children (from birth to five) questions how cultural and linguistic factors were addressed as this population of children are the fastest growing in the USA. In 2015 over 50% of all babies born are CLD. Culturally-responsive interventions are defined as "those that incorporate the values, beliefs, practices, experiences, and materials relevant to the cultural backgrounds of the individuals receiving the intervention across all aspects of the intervention" (Larson et al., 2020, p.158). Interventions deemed linguistically responsive intentionally support use of children's home language. For example, coaching parents in how to implement language-promoting strategies (Peredo, Zelaya, & Kaiser, 2017). Interventions focused on four areas: explicit instruction on targeted skills e.g. teaching vocabulary, using individualised or small group instruction therefore providing more opportunities for the extended, scaffolded 'serve and return' interactions (see Romeo et al., 2018); classroom curriculum interventions; interactive book reading and/or book making interventions; and naturalistic, routines-based interventions. With the exception of naturalistic, routines-based interventions, for which child outcomes were not examined, nearly all interventions in the other three categories were successful in promoting varied language and/or literacy skills of children. A key finding was that all language promoting interventions that were both linguistically-and culturally-responsive had positive effects. These promising findings are particularly relevant for CLD children attending ECEC

programmes, suggesting that "improving access to high quality early care and education should be a high priority of policymakers" (Larson et al., 2020, p.175).

However, ECEC must provide cultural or linguistic adaptations to significantly affect language outcomes in the home language or English. Support for children's home languages is not only important for children's cultural identity and family ties but can also lead to long-term academic gains (Arellano et al., 2018). In order to support the home language, delivering interventions directly in ECEC settings through an interpreter or involving bilingual/ bicultural support staff is suggested. Early childhood educators could draw from and involve parents and other cultural representatives in learning about cultural values, beliefs, experiences, practices including interactions and materials (their funds of knowledge) to enable planning and implementing child language supports, whilst avoiding tokenism and cultural stereotyping. Formal strategies, such as ethnographic interviewing (e.g., Hammer, 1998) can be used to gather information about cultural values and norms. For example, early childhood educators may explore adaptations to book interventions with families who may engage more in oral storytelling. Three limitations of the study were addressed: the studies did not include the variety of CLD populations and infants and toddlers; methodological inconsistencies limited comparisons and full effectiveness evaluation across studies and only a handful of studies have considered cultural factors in intervention design and implementation including measuring participant engagement and social validity.

Young children in Ireland come from a diversity of family backgrounds. Census 2016 revealed that we have 182 languages in Ireland and one out of 10 children speak an additional language (Central Statistics Office, 2018). Background can refer to an individual's ethnicity, culture, religion and language of origin, in addition to SES. Professional practices in ECEC, ideally, reflect the values and beliefs of the families and the cultures of their communities (Dalli et al., 2011). Respect-based partnership with parents (and carers) is key, which means deeply engaging with parents and in practices that promote diversity and inclusion. This involves sharing of information, skills, decision-making, responsibility and accountability.

Multi-tiered systems of support for language, literacy and numeracy

Shepley and Grisham- Brown (2019) conducted a meta-analysis on multi-tiered systems of support (MTSS) in early childhood. MTSS is a prominent feature of practice and research in USA grade schools (kindergarten to 12th grade) and can be defined as "a proactive

model through which struggling students may receive targeted interventions" at increasing levels of intensity to accelerate their rate of learning, "without the need for a special education label" (Shepley & Grisham- Brown, 2019, p.298). Tier 1 interventions involves general education through high-quality research-based classroom instruction; Tier 2 involves targeted interventions for students not making adequate progress in the core curriculum in Tier 1 and likely to include small-group learning experiences and Tier 3 involves individualised intensive interventions. The field of ECEC in the USA has endeavoured to adopt MTSS. However, this has not been without challenge. Early childhood settings in the USA have particular challenges which resonates with the Irish situation including: a) diversity of settings, funding streams, professional education, and curricula leading to variation in intervention fidelity; b) early childhood curricula will contain a mix of child-initiated learning experiences as well as adult-initiated responsive interaction interventions, which is incompatible with grade school's adherence to a research-based core curriculum primarily consisting of teacher-led activities; c) many interventions at grade school are inappropriate in ECEC settings e.g. targeting reading comprehension; d) in the USA, in elementary schools there is great emphasis on the role of the special educator in collaboration with the general educator whereas in ECEC settings early childhood educators are dual certified in early childhood and early childhood special education. It should be noted that in Ireland we have the successful Access and Inclusion Model[1] initiative in ECEC settings.

Of relevance to the Irish context is the response to the research question which focussed on how effective are MTSS for preschool-aged children across commonly evaluated developmental/content domains? The domains included expressive language, receptive language, letter recognition, listening comprehension, phonological awareness, print knowledge, rhyming, challenging behaviour, engagement and social skills. The purpose of the meta-analysis was to provide stakeholders with guidance on development and implementation (Shepley & Grisham- Brown, 2019, p.298). When considering all study-level effect sizes, statistically and clinically significant findings are evident for literacy and social–emotional outcomes. However, looking at only the most rigorous studies, these effects

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[1] AIM commenced in 2016. The goal of AIM is to create a more inclusive environment in ECEC settings, so that all children, regardless of ability, can benefit from quality ECEC. Universal and targeted supports are provided, which focus on the needs of the individual child, without requiring a diagnosis of disability. Tens of thousands of children with a disability have been supported to access and meaningfully participate in the Early Childhood Care and Education programme in ECEC settings nationwide. See https://aim.gov.ie/ for more information.

typically lessened or were infrequently detected. Therefore, the authors are hesitant to provide guidance on system-wide MTSS models targeting literacy and language. There was an emphasis on small group instruction but limited information across the studies to examine differences meaningfully or allow replicable descriptions of small group intervention. The inclusion and exclusion criteria for selecting dual language learners in studies were not specified clearly, which should be remedied in future studies. Twelve out of the 16 studies focused on just one Tier rather than multi-tiered approaches. Statistics were not reported adequately leading to a potential over-estimation of the effect sizes. It should be noted that none of the studies incorporated mathematics among their targets despite the acknowledged importance of incorporating mathematics into ECEC MTSS models. Marginal evidence of effects was reported regarding literacy and language outcomes, targeted in rigorous research designs. "More rigorous research is needed with a focus on interventions and practices that are established and align with the delays of individuals needing tiered services based on a formal assessment process" (Shepley & Grisham- Brown, 2019, p.307).

Impact of scaled up and tutoring interventions on numeracy and literacy

In the USA context, a systematic review and meta-analysis of methodologically rigorous studies on the short term effects of 10 scaled-up funded pre-kindergarten programmes on young children's mathematics and reading achievement in kindergarten was conducted (DeAngelis et al., 2018). The goal of the programmes is to reduce the considerable academic achievement gaps between young children at risk of educational inequality and their advantaged counterparts and to provide access to quality ECEC. Despite previous contradictory findings on the impact of ECEC on later outcomes, the authors reported that the "results are unambiguous: these scaled-up pre-K programmes have large positive impacts on mathematics and reading test scores in the year following the intervention" (DeAngelis et al., 2018, p.514). The authors do not indicate the success criteria of the various programmes. However, it is possible to state that where reported (nine out of the 10) programmes require educators to be qualified to degree level and certified in ECE; some educators also receive compensation equal to that of public school teachers; when adult child ratios are included they are from one adult to eight children or from one to ten. The authors recommended the ECEC should be offered based on the importance of intellectual stimulation for very young children and on the positive short-term effects of pre-K programmes combined with rigorous longitudinal experimental research to determine the long-run impacts of programmes in the future (DeAngelis et al., 2018).

What to consider when selecting numeracy interventions in early childhood

In the context of the USA, Nelson and McMaster (2019, p.195) provide evidence that "students from low SES backgrounds and students who are English learners (ELs) may be at increased risk of low achievement in math". Proficiency in maths is associated with retention in education, higher earnings and rates of employment (Gaertner et al., 2014). Nelson and McMaster (2019), who reviewed early numeracy interventions to guide educators and policy makers in the variables to consider when selecting interventions signify that it is critically important that young children achieve mastery of mathematics concepts from pre-school to the equivalent of first class (Nelson & McMaster, 2019). Indeed, it is argued that the foundations for maths develop from birth (French, 2012; MacDonald & Murphy, 2021). Only four of the 20 studies focussed on ECEC (from age three years). Early numeracy, which features a set of foundational skills in understanding whole numbers (such as quantity, counting, comparison) contains the building blocks to learning more complex skills such as addition and subtraction. Nelson and McMaster (2019) report that interventions are effective at improving students' math achievement.

Reviews highlight the effectiveness of using multiple representations (pictures, talk, symbols) to teach math content, especially with students with a math disability (e.g., Jitendra et al., 2016), explicit and systematic instruction and computer-assisted instruction (e.g. Mononen et al., 2015). Nelson and McMaster (2019) examine relevance (results that can be generalized to their population of students e.g. low SES and ELs) and impact (close/proximal alignment of the outcome measures to the intervention rather than distal and more removed alignment) to investigate features of interventions to consider when selecting or designing interventions to meet their students' needs. The results of the Nelson and McMaster study suggest that early numeracy interventions are effective in improving students' math performance; however, more research is needed to determine the degree to which participants' characteristics impact the effectiveness of intervention programmes. The authors recommend that future intervention studies should consider including disaggregated results for ELs and for students from low-SES backgrounds. More investigation into how math vocabulary is taught and integrated into early numeracy programmes is warranted; more pointed information to support students from culturally and linguistically diverse backgrounds is needed. Educators are advised to consult with school-based experts (such as psychologists), the authors of the interventions and guides to interventions such as the What Works Clearinghouse to determine whether the study was representative of the students who are to receive the intervention and to

closely monitor the progress of students using multiple measures. This is important because early "numeracy skills are fundamental to students' future math achievement, so it is vital that practitioners have resources to investigate studies, intervention reports, and reviews of interventions to make the best decisions for their students" (Nelson & McMaster, 2019, p.205).

Predictors of successful transition to school and the importance of play

Some studies in this review are rooted in the concept of 'school readiness' particularly in the context of the USA (DeAngelis et al., 2018, Joo et al., 2020; Linder et al., 2013). 'School readiness' was defined as "as children's preparedness for what they are expected to know and do in academic domains and processes of learning when they enter a formal classroom setting" (Linder et al., 2013, p.1). Linder et al (2021) focussed on school readiness in the areas of literacy and mathematics to provide understanding of the factors that have been identified through research that may contribute to children's successful entry into formal schooling. Appropriate components such as children's social-emotional characteristics, cognitive processes related to conceptual understanding, and their ability to communicate about their understandings were considered, rather than knowledge of the alphabet or counting. The authors found more literature on literacy than on mathematics and therefore suggest there could be gaps in knowledge in relation to early mathematics. Seven themes on children's preparedness for the successful transition to school emerged: (1) child care experience, i.e. exposure to high-quality ECEC curricula (although not always defined) where educators scaffold tasks, offer a variety of spaces for play and materials to encourage exploration, and opportunities for discussion and communication, had positive outcomes on measures of literacy and numeracy; (2) parenting style, i.e. family structure and parental warmth combined with value for education and high expectations for children's learning (as high a predictor as SES); (3) home environment i.e. exposure to limited informative/educational TV and active literacy in the home – shared reading, rhymes - significantly related to young children's oral language ability, word decoding ability, and phonological sensitivity; (4) learning-related personal characteristics i.e. children's dispositions and strategies related to engaging and completing tasks. Positive attachment patterns, self-regulation and social competence predicted mathematics and reading achievement between kindergarten and sixth grade; (5) social behaviour i.e. characteristics such as being active, sociable, collaborative and an effective communicator; (6) experience of mathematical and literacy-based tasks i.e. positive correlations exist between tasks that encourage children to use counting skills and begin to explore quantities and make

comparisons, informal board game play, building spatial sense through block play (including Duplo and Lego) and later academic achievement (in reading as well as mathematics); examining literacy related concepts such as phonological awareness, decoding, awareness of print, and letter identification can lead to higher levels of literacy success and (7) health and socioeconomic status i.e. health, birth weight and gender of the child (boys are twice as likely to struggle with transition to school compared to girls) were the strongest predictors of school readiness. Low SES has been consistently negatively correlated to school readiness in the research literature (Linder et al., 2013).

In the context of the USA, Linder et al. (2013, p.5) articulated that "it is unclear whether the view that students should be ready for school rather than schools being ready for children is developmentally appropriate". 'School readiness' is a debated and contested concept in Western Europe. Bingham and Whitbread (2018, p. 364) argue that the 'schoolifying' of the ECEC years "is not supported by the research evidence and that it is very likely to be damaging, particularly for the most deprived and youngest children". They conclude that the real issue is determining how to meet the children's socio-emotional needs in a smooth transition to school and consistency in teaching methodologies that include a play-based curriculum (physical, constructional and social play), child-initiated experiences and responsive interactions in ECEC settings and primary school–until at least the age of 7 years. The benefits of play and, in particular, its critical role in early brain development, have been increasingly discussed, emphasised and included in early childhood education policy (United Nations Children's Fund, 2018). For example, when children are playing in an imaginary shop "children use mathematical abilities and oral language skills, and word games are a chance to practice their literacy skills" (Jensen et al., 2019, p.4). The evidence from a range of intervention studies indicates that supporting families living in poverty or at risk of educational inequality to enable them provide enhanced early experiences for the children is productive. "It is not who parents 'are' but what they do to support their child that makes the difference to their development" (Bingham & Whitbread, 2018, p.383). Indeed, in the Hart and Risley study (1995) there were disparities noted in the amount of language that caregivers in different families directed to young children at various SES levels.

Melhuish et al. (2015, p. 55) revealed that research "based on the tradition of emergent literacy and numeracy, has shown that child-following, playful and authentic activities in literacy and numeracy grant children initiative, and can be used to effectively

introduce children into academic subjects". What we do not know, and is a challenge in early childhood practice, is how to support the type of play which best extends children's thinking while dealing with the dichotomy between child-initiated play with no adult-involvement, and overt didactic rote learning. This dichotomy has been addressed in a recent comprehensive review of 26 peer-reviewed published experimental and quasi-experimental evaluations of play interventions that have demonstrated causal impact on learning and the closing of achievement gaps through play and 20 key informant interviews in 18 countries (Dowd & Thomsen, 2021).

The five key characteristics of learning through play are: active engagement, meaningfulness, opportunities for repetition, joyfulness and opportunities for socialisation (Zosh et al., 2018). The findings suggest a connection between child choice, enjoyment, exploration, perseverance and learning. It is noted that when new or very complex concepts are introduced to young children play is not the only option for learning, children observing and "high-quality instruction is especially important for their learning" (Jensen et al., 2019, p. 11). The facilitation approaches recommended include: free play, guided play, games, and some forms of quality instruction such as explanation with concrete examples, modelling a new skill while talking through the process and engaging children in discussion (Jensen et al., 2019). The facilitation strategies employed in the interventions that reduce inequality include: guided and free play and provision of child choice in the classroom. In guided play, an adult extends the free play of children or defines the outcomes and provides guidance and reflection, but the child directs the approach and activities (Hassinger-Das et al., 2020). Vogt et al. (2018) compared playing games with a training programme to promote mathematics learning; all but one teacher using games reported they would use them the following academic year, whilst only 50% of teachers would use the training programme. Five different types of play were identified: play with objects, physical play, games with rules, symbolic play, and pretend play (Whitebread et al., 2017). The review revealed that different types of play can promote learning in a range of academic domains and could be an effective strategy to close achievement gaps for children ages three to six years. However, it is acknowledged that play "is not taken seriously as an inclusive solution to the development of children's knowledge and holistic skills…More often, play is seen as something separate from the seriousness of school and work" (Dowd & Thomsen. 2021, p.8). The authors recommend that the role of learning through play needs to be elevated to counteract inequality in children's

outcomes and opportunities and should be an integral part of any government policy aimed at giving children greater skills and knowledge in their early years (Dowd & Thomsen 2021).

Four areas for future investment, investigation and innovation are suggested: provide more guided and free play in poorly resourced contexts; trial ways to increase play in early childhood interventions; study early childhood interventions through an applied playful lens and deliver longitudinal studies of play in early childhood. Finally, the studies show that different types of play can promote learning in different settings.

Conclusion

This review focusses on language, literacy and mathematics for children from birth to six years of age in the context of poverty and educational inequality. Early childhood represents an "exceptionally powerful opportunity to break intergenerational cycles of inequity" (United Nations Children's Fund, 2019, p. 39). We know that such adversity may undermine young children's opportunities to achieve their full potential (National Scientific Council on the Developing Child, 2020). A lack of "mental nutrition" can compromise the developing brain, with lasting consequences for children's ability to build the social, emotional and academic skills they will need to flourish (Fernald & Weisleder, 2015, p.3). In relation to ECEC "there is agreement, across studies, that good relationships, interactions, talk and narrative, play an essential role in children's learning – their social and emotional development, as well as their development of language, literacy, and cognitive and mathematical development" (Melhuish et al., 2015, p. 55). Given the apparent correlation between the home learning environment and ECEC quality and children's successful transition to school, initiatives to enhance the home learning environment and ECEC and educator quality could promote children's literacy and mathematics (Linder et al., 2013).

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Author Biography

Dr Geraldine French *is an Associate Professor, Head of School of Language, Literacy and Early Childhood Education (ECE), Programme Chair of the Master of Education in ECE at the Institute of Education, DCU and Senior Fellow of Advance HE (SFHEA). Geraldine was commissioned to undertake reviews of literature on the key elements of professional practice in relation to children under three years by the National Council for Curriculum and Assessment and reviews underpinning both national frameworks Aistear and Síolta which focus on ECE. She has published extensively in the areas of quality professional practice in ECE, early literacy, numeracy, speech, language and more recently relational pedagogy with babies.*

Appendix Research strategy and Tabulation of Results

Overview

This review synthesises the literature on supporting children at risk of educational inequality in developing literacy (digital literacy) and numeracy in early childhood education and care (ECEC). Despite compelling evidence that children engage in language, literacy and mathematical experiences from birth there is a dearth of reviews which focus on children from birth to four years, particularly in the mathematical context (MacDonald & Murphy, 2021). Studies demonstrate that for young children, particularly those who face adversity, poverty and educational inequality, high quality Early Childhood Education and Care (ECEC) can lead to better school achievement, higher cognitive test scores, less special education placements and higher school retention rates (Organisation for Economic Cooperation and Development, 2018; Taggart et al., 2015). In the systematic searches that underpinned this review 15 of the reviews focussed on children from three years; while only three reviews focussed on children from birth implying a significant gap in the research. This review responds to the following research questions.

Research questions

1. What strategies support children from birth to six years, at risk of educational inequality in developing literacy, including digital literacy?

2. What strategies support children from birth to six years, at risk of educational inequality in developing numeracy?

Key Data Sources Consulted

- SCOPUS, ERIC, Education Research Complete
- Web of Science (language and emergent literacy)
- Google Scholar
- Handbooks in the field published since 2011
- 'Grey literature' (for example, Organisation for Economic Cooperation and Development, United Nations Children's Fund)

Key Search Terms Literacy

(early childhood education or preschool or kindergarten) AND (emergent literacy or early literacy or beginning reading or beginning writing OR early intervention) AND (teacher effectiveness OR pedagogical content knowledge OR instructional improvement OR instructional innovation)

(early childhood education or preschool or kindergarten) AND emergent literacy AND (teacher effectiveness OR pedagogical content knowledge OR instructional improvement Or instructional innovation) AND (meta-analysis or systematic review or literature review)

Suggested 1:

(early childhood education AND (literacy or reading or reading skills or literacy skills) AND TI review

Suggested 2:

early childhood education AND (teachers or educators) AND (literacy or reading or reading skills or literacy skills) AND TI (review of literature or literature review or meta-analysis or systematic review)

Inclusion Criteria (abstract & title search)	Exclusion criteria (abstract & title search)
Systematic review or meta-analysis Best-evidence Synthesis Oral language ORAL communication LANGUAGE acquisition CHILDREN'S language VERBAL ability OR COMMUNICATIVE competence EMERGENT literacy LITERACY programs LITERACY education FUNCTIONAL literacy Early childhood education Post 2011 Pedagogical strategies	Predominant focus on something other than education (e.g., health literacy) Medical Medicine Autism Parent Post-primary Secondary High School Higher-education Speech pathology Speech and language Unpublished theses Books, except specific Handbooks Book review Preservice teachers Student teachers Single case study not sufficient for inclusion unless relevant to under-represented disciplinary area (oral language, emergent literacy) or age-range (early childhood)

See Prisma chart overleaf

*Records excluded following blind review by two reviewers using Covidence

Prisma Chart Early Literacy
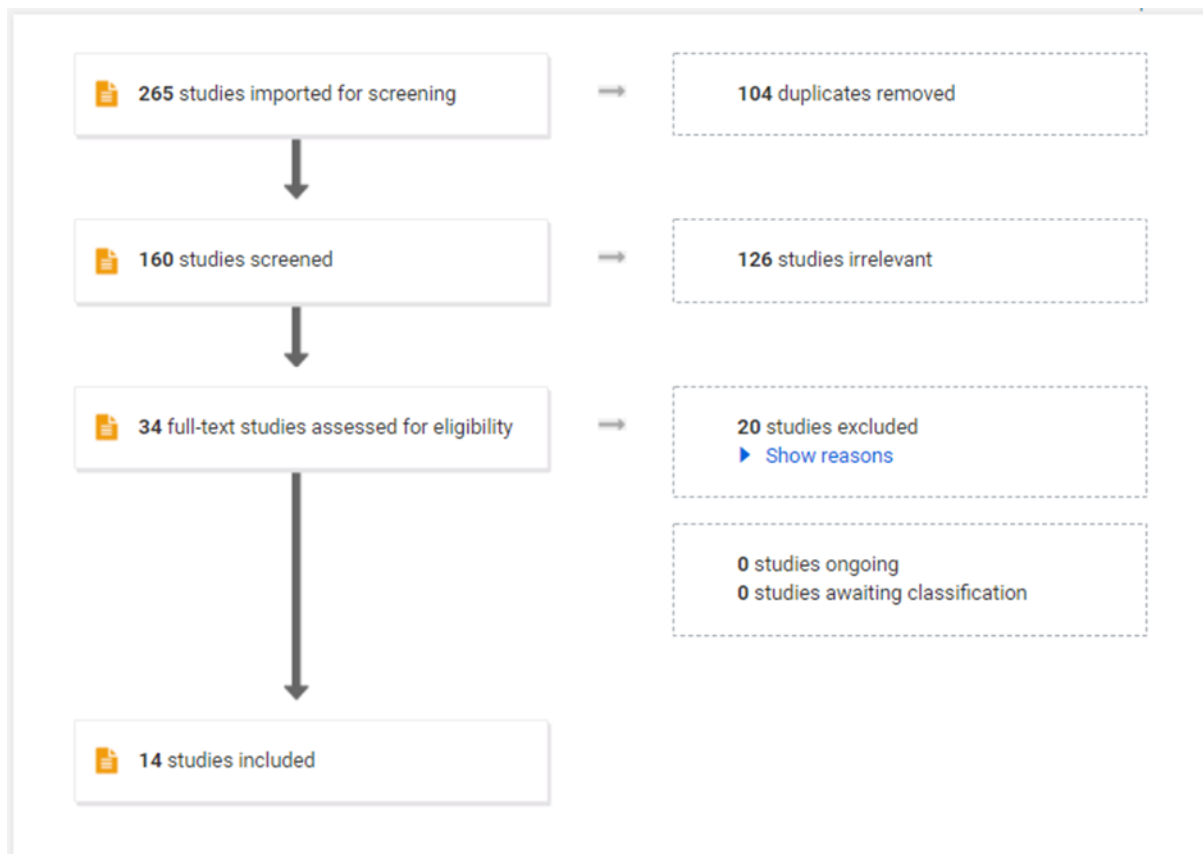
In relation to early numeracy two systematic reviews included literacy and numeracy (DeAngelis, Holmes Erickson & Ritter, 2018; Linder, Ramey & Zambak, 2013) and two focussed on early numeracy only (MacDonald & Murphy, 2021; Nelson, & McMaster, 2019) and were added to this review.

Tabulation of Results in Early Childhood Education and Care Literacy (including Digital literacy) and Numeracy

Review	No of studies	Effect size (If available)	Theme	Age range	Findings
Christ & Wang (2011)	31	Not reported	Children's vocabulary learning	4 – 6 years	In the context of children at risk for educational inequality and a desire to close the vocabulary gap identified by Hart and Risley (1995), three main approaches were found in this review to be used in early childhood classrooms to support children's vocabulary learning—purposively exposing children to advanced words, directly teaching children the meanings of words and employing multiple methods interventions. These practices support children's learning of targeted vocabulary words and/or general vocabulary knowledge gains, but various methods have differential impacts on children's depth of word knowledge. Theme-based multi-method interventions are the most likely approach to close the gap.
Chambers, Cheung & Slavin (2016)	32	From +0.15-0.08	Comparison of comprehensive language intervention versus development oriented programmes	3-5 years	The findings support the idea that young children learn best in comprehensive programmes that balance skills-focused and developmental activities. Programmes that focus on developmental constructivist, child-initiated activities but do not incorporate teaching of phonemic awareness and phonics skills had lower effect sizes than did those that had a focus on early literacy skills as well as developmental activities, in areas of high poverty.
Ciesielski & Creaghead (2020)	15	From d = -0.02 to 1.94	Impact of PL/D on early childhood educators on children's phonological awareness	3 - 6 years	Aspects of effective professional learning and development (PL/D) including the education and experience of the ECEs, the format and structure of the PL/D, and the content of the educational program, are considered. The findings have important instructional implications in the context of educational inequality. In general, educational programs that were highly structured, providing specific, defined activities including scope, sequence, and wording, were more successful. Educational programmes using scripted activities or highly detailed lesson plan scopes and sequences resulted in the greatest gains in PA skills. Programmes demonstrating the highest ES's as were those designed to be incorporated into the existing preschool programme.

DeAngelis, Holmes Erickson & Ritter (2018)	7	The effect sizes ranged from 0.19–0.70 standard deviations for mathematics and 0.26–1.01 standard deviations for reading	Effects of funded programmes (US) on mathematics and reading achievement	3-4 year olds	The existing evidence and compute meta-analytic averages for the effects of scaled-up, publicly funded pre-kindergarten (pre-K) programmes in the United States on student mathematics and reading achievement are systematically examined. The analysis is restricted to experimental and quasi-experimental research designs with the highest internal validity. The short-term cognitive effects of pre-K are synthesised and large positive effects of scaled-up public pre-K programmes on student pre-kindergarten test scores from seven studies were found. In particular, the overall effect on mathematics scores is over a third of a standard deviation and the overall effect on reading scores is three-fifths of a standard deviation. More research is needed on the sustained effects of pre-K as policy makers debate whether to expand or adopt such programmes. [ABSTRACT FROM AUTHOR]
Dowd & Thomsen (2021)	26 ECEC evaluat-ions and 20 key inform-ant inter-views with authors of the studies	Not reported	Learning through play: increasing impact, reducing inequality	3-6 years	This literature review explores the role of play in contributing to the effort to promote learning and reduce inequality. It builds on the characteristics of learning through play, the play types and facilitation approaches addressed in past reports and recasts the evidence to inform recommendations for future work. The majority of interventions that close achievement gaps include free and guided play and enable child choice in the classroom. However, the use of free and guided play in classrooms required time and support to help teachers implement and sustain them. Recommendations include the pursuit of more free and guided play in resource constrained contexts, the testing of incremental and disruptive ways to increase play in early childhood interventions, the launch of longitudinal studies of play in early childhood, including a breadth of skills with a focus on fade-out, and the application of this playful lens in studies of early primary interventions. Learning through play could be an effective strategy to close achievement gaps for children ages 3 to 6 years.

| Dowdall, Melendez-Torres, Murray, Gardner, Hartford, Cooper, & Melendez-Torres (2020) | 20 | Expressive language (d = 0.41); receptive language (d = 0.26); caregiver book-sharing competence (d = 1.01). | Shared picture book reading interventions for child language development | 1-6 years | Interventions that train parents to share picture books with children are seen as a strategy for supporting child language development. A strong argument could be made that book-sharing should be considered for any program that seeks to support early literacy and language development in infants and young children. It is especially significant that the current analysis indicates that book-sharing interventions can be equally effective when targeted at caregivers with low and high levels of education. It is also notable that, contrary to previous suggestions, the current analysis indicates that young and older preschool children benefit equally from these interventions. Finally, this analysis suggests that there is a dose effect, with brief interventions being unlikely to result in improvements in children's language abilities. Interventions involving multiple sessions, on the other hand, with extended contact time between the instructor and caregiver, are highly likely to result in improvements to child language. This review and meta-analysis confirms the promise of book-sharing interventions for enhancing and accelerating child language development. |
| Hall, Simpson, Guo & Wang (2015). | 18 | Maturationists (1 study) Hedges g = .94 Constructivists /interactionists (5 studies) Hedges g =.07 - 1.44 Environmentalist/ Behaviourist (7 studies, 13 interventions) Hedges g=.91) 1 Hedges g=.6-.21) 7 Hedges g=.06-.18)5 | Preschool writing instruction on emergent literacy skills | 3 to 5 years | Although expectations for young children to write have increased significantly in recent years and support exists for engaging preschool children in meaningful writing experiences, little information exists regarding effective writing instruction in the preschool setting. This is a systematic review of experimental studies investigating preschool writing instruction along with a meta-analysis component. Although dependent variables differed greatly among the 18 studies included in this systematic review, the effectiveness of writing instruction on children's emergent literacy outcomes was found to be relatively large in 11 out of 22 intervention conditions regardless of the philosophical approach supporting writing instruction. Specifically, few experimental studies have been conducted with interventions focused solely on preschool writing instruction. |

Joo, Magnuson, Duncan, Schindler, Yoshikawa, & Ziol-Guest (2020).	124	Mean ES, unweighted & weighted Parent, 0.8 (0.9) 0.3 (0.4) Curricular 0.4 (0.5) 0.3 (0.4) Professional development 0.2 (0.4) 0.2 (0.3)	Effects of adding ECE enhancement programmes to existing programmes (parent, curricular and professional development) on 1) language/ literacy specific, 2) math specific, and 3) other content specific comprehensive curricula.	3 to 5 years	This study uses data from a comprehensive meta-analytic database of ECE programme evaluations published between 1960 and 2007 in the United States to examine the incremental effects of adding enhancement program components to ECE programs on children's cognitive abilities, pre-academic skills, behavioural, health, and socio-emotional outcomes. Findings suggest that the addition of parent programs and skill-based curricula to ECE programs can result in improvements to a range of children's ECE outcomes leading to better school readiness. No differences in the impacts of ECE programs with or without additional professional development enhancements were found. Designing fully-developed parent programs by explicitly targeting parents, developing academically focused and skill-based curricula, and providing additional teacher professional development enhancements to existing ECE programs can have a substantial impact on a range of children's ECE outcomes leading to better school readiness. Further research is needed in order to determine what conditions are essential to enhancement program success as well as what conditions have negligible effects on or inhibit children's school readiness. [ABSTRACT FROM AUTHOR]
Kelly, Wakefield, Caires-Hurley, Kganetso, Moses & Baca (2021)	56	Not reported	Culturally responsive, or culturally sustaining literacy instruction	4 – 10 years	This critical, integrative qualitative review explores how researchers approach, describe, and justify culturally relevant, culturally responsive, or culturally sustaining literacy instruction. Researchers most commonly claim to document culturally relevant or responsive instruction, in some cases conflating the terms and related theorists. Most studies were qualitative, occurred with traditionally marginalized students (usually Black or Latinx) in the US, and involved students reading a text that researchers deem culturally informed. [ABSTRACT FROM AUTHOR]

| Larson, Cycyk, Carta, Hammer, Baralt, Uchikoshi, An, & Wood (2020) | 40 | 0-2 | Interventions for improving language outcomes for young, culturally and linguistically diverse children | Birth to 5 years | This synthesis described and analysed studies examining interventions for improving language outcomes for young, culturally and linguistically diverse (CLD) children. Interventions focused on four areas: explicit instruction on targeted skills; classroom curriculum interventions; interactive book reading and/or book making interventions; and naturalistic, routines-based interventions. A key finding was that all language promoting interventions that were both linguistically-and culturally-responsive had positive effects. Several cultural or linguistic factors were also identified as variables affecting intervention fidelity, engagement, and effects. [ABSTRACT FROM AUTHOR] |
| Linder, Ramey & Zambak (2013). | 37 | Not reported | Predictors of school readiness in literacy and mathematics | Pre-school | This paper presents findings from a selective review of the literature related to predictors of school readiness in literacy and mathematics. School readiness was defined as what children are expected to know and do in a variety of academic domains and processes of learning prior to entering a formal classroom setting. In general, literature relating to predictors of success in early childhood literacy was more prevalent than literature relating to early childhood mathematics. Therefore, more predictors of success relating to literacy were identified in this review. Seven themes emerged from the literature review regarding factors associated with school readiness in mathematics and literacy: (1) child care experience; (2) family structure and parenting; (3) home environment; (4) learning-related skills; (5) social behaviour; (6) mathematical and literacy-based tasks; and (7) health and socioeconomic status. Twenty-four predictors of success for school readiness were categorized under these themes. |

MacDonald & Murphy (2021)	103	Not reported	Mathematics education	Birth to 4 years	Despite growing international research evidence about young children's engagement with mathematics education, much of this evidence is drawn from children aged from four years. This paper reports findings from a systematic review of peer-reviewed international research concerning mathematics education for children aged under four. The majority of the studies took place within an early childhood education service such as a preschool or day care centre, and task-based interviews and standardised assessments were most commonly used. Most of the papers focused on either educators' knowledge, attitudes and strategies, or children's mathematical competencies. Children do engage in mathematics education prior to four years of age, and that they possess many mathematical competencies. Findings suggest that educators play a critical role in shaping the mathematical learning opportunities available to children; however, there is some uncertainty among educators about how to support young children's mathematics learning.
Markussen-Brown, Juhl, Piasta, Bleses, Højen & Justice, 2017	25	Process, structural quality & knowledge (1.07); receptive vocabulary (0.21); phonological awareness (0.30); and alphabet knowledge (0.12) no relationship between educator outcomes and child outcomes ($p = 0.338$)	The effects of language- and literacy-focused professional development on early educators and children	Early child-hood	Professional learning and development (PL/D) is increasingly used to improve early childhood educators' skills and knowledge in providing quality language and emergent literacy environments for children. However, the literature does not clearly indicate the extent to which such efforts reach their goals, or whether improvements in educator outcomes translate to learning gains for children. A meta-analysis was conducted to evaluate the effects of language- and literacy-focused PD on process quality, structural quality, and educator knowledge as primary outcomes. Furthermore, effects for three child outcomes: receptive vocabulary, phonological awareness, and alphabet knowledge were estimated. The total number of PL/D components was the strongest predictor of process quality. The results suggested that PL/D is a viable method of improving language and literacy processes and structures in preschools, but effects may need to be substantial if they are to translate into higher child outcomes.

Marulis, & Neuman (2013)	51	138 effect sizes (N = 7,403)	Examines how word-learning interventions affect young children, at risk for reading difficulties, on vocabulary outcomes	4-6 years	Children from low-socioeconomic-status (SES) families experienced significantly lower word-learning gains than those advantaged families who had one or more risk factor (e.g., English Language Learner, language delays). Further, multivariate meta-regression analyses indicated that the sole risk factor associated with lower effect sizes was poverty controlling for all other risk factors. Subgroup moderator analyses indicated a number of instructional and pedagogical factors associated with greater effect sizes. Taken together, these results highlight the importance of creating interventions powerful enough to accelerate children's vocabulary development if we are to narrow the reading achievement gap.
Mol & Bus, 2011	99	Print exposure explaining 12% of variance in oral language skills	Relationship between print exposure and oral language	3-20 years	Shared book reading to pre-conventional readers may be part of a continuum of out-of-school reading experiences that facilitate children's language, reading, and spelling achievement throughout their development.
Nelson, & McMaster, 2019.	20	Distal measures (g = 0.35; SE = 0.05), or when studies reported including more than 30 percent of participants as English learners (g=0.44; SE=0.12).	Review early numeracy interventions to provide practitioners with important information and variables to consider when reviewing intervention reports and selecting interventions.	3-7 years	Despite encouraging findings that show that interventions can improve students' math understanding, achievement gaps in math often persist or even widen for students who struggle. Educators play a significant role in closing these achievement gaps because they have the responsibility to select or design interventions. Practitioners may wish to consider factors that influence intervention effectiveness. This study evaluated numeracy interventions and explored how features of the studies and interventions may have influenced reported effects. Results indicated variable effects across the same intervention programs. When practitioners select interventions for their students, they must consider features of the published studies, including which outcome measures researchers used to determine the effectiveness of the intervention, the population of students, and the variability in effects for the same intervention program across studies.

Shepley & Grisham-Brown (2019)	16	Mean ES Expressive L (0.16) Receptive L (0.05) Letter recognition (0.79), Listening comprehension (0.50) - Phonological awareness (0.05), print knowledge (0.24), Rhyming (0.40) Challenging behaviour (0.51), engagement (0.59) social skills (0.55)	MTSS for expressive & receptive language, letter recognition, listening comprehension phonological awareness, print knowledge, Rhyming, Challenging behaviour, engagement & social skills (from -0.10 -1.09)	4 - 5 ¼ years	Multi-tiered systems of support (MTSS) have been a prominent focus of research and practice in grade-schools in the US given that they provide a proactive model through which struggling students may receive targeted interventions without the need for a special education label. In early childhood education there are factors that have inhibited the implementation of these tiered support systems (diversity of settings and professional development; incompatibility with grade school teacher directed approaches versus child-initiated approaches; inappropriate use of reinforcement systems given the social and developmental variability amongst young children, among other challenges). However, there is a drive to adopt MTSS in ECEC. Findings indicate that various types of outcomes have been commonly investigated with effects ranging in impact. Tiered support systems targeting social–emotional development were most successful. Given variable findings, cautious recommendations are offered for individuals involved with multi-tiered systems of support in early childhood education. [ABSTRACT FROM AUTHOR]
Wasik, Hindman & Snell (2016)	36	Not reported. Downs & Black (1995) scoring system of the quality of the studies reviewed was applied. The 36 studies' overall quality was 19.0 out of a total possible score of 25.	High-quality empirical studies on book reading practices in early childhood that have resulted in increases in child vocabulary	3 – 6 years	This paper reviews high-quality empirical studies on book reading practices in early childhood that have resulted in increases in child vocabulary. Six strategies—reading and re-reading texts, explicitly defining words, encouraging dialogue about book-related vocabulary through questions and discussion, re-telling, using props, and engaging children in post-reading activities—are consistently implemented across the studies; however, they are used in widely varying combinations. Variability across studies in the number of words taught, the criteria for word selection, and the measures used to assess word learning is evident. In many studies, children learn only a small proportion of the number of words taught. Finally, this review identifies critical remaining questions about how to optimize vocabulary learning through book reading that require systematic investigation in order to inform effective practice. [ABSTRACT FROM AUTHOR]