PARENTS AS FACILITATORS OF YOUNG CHILDREN'S STEAM LEARNING IN EARLY CHILDHOOD: A LITERATURE REVIEW

Report prepared by the 'Doodle STEAM' team for the Childhood Development Initiative, first circulated to Advisory Group on 12.04.22 and finalised on the 11.07.2022.

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INTRODUCTION

This systematic literature review provides a critical overview of peer-reviewed research on parents as important facilitators of young children's early engagement with STEAM. The aim of the review is to inform the development of educational resources to support parents engage in STEAM learning activities at home. The objective of the review is to identify evidence-based components of an effective STEAM educational programme to support parents of children aged 6-8 in their STEAM learning.

The literature review adopts a systematic approach to literature searches to answer two pre-specified research questions. Searches of scholarly databases were undertaken to answer the following major research questions: (1) How do parents view early STEAM learning and engagement and how confident are parents in supporting young children in STEAM activities; and (2) What educational approaches have been found to support parental engagement in STEAM learning with young children?

The literature review provides a brief background on the concept of STEAM, how it is currently defined and why it is considered important in Early Childhood Education. Background context as to why parents are particularly important in supporting early STEAM learning is also provided. A brief methodology section outlines the systematic approach taken to searches and databases used.

The findings section outlines the results of these searches as they pertain specifically to each of the two research questions. Findings are discussed through narrative synthesis. The report concludes with a brief summary of the key findings that will inform the development of educational resources for supporting parents in STEAM learning at home.

Defining STEAM: Science, Technology, Engineering, Arts and Mathematics

STEAM originates from the STEM acronym which stands for Science, Technology, Engineering and Mathematics. The acronym becomes STEAM with the inclusion of A for the Arts. Sharapan (2012) defines each aspect of STEAM in an accessible way as: "science is about nurturing a sense of wonder"; "technology is a fancy word for tools"; "engineering starts with identifying a problem, then moves ahead to thinking about solutions and trying them out"; and "mathematics is much more than counting, it is also comparing, sorting, working with patterns, and identifying shapes" (Sharapan, 2012, p.37). The main idea behind STEAM is to integrate all the disciplines together rather than focus on them separately. The inclusion of the Arts is considered especially important and effective for teaching STEM concepts in early childhood education (ECE) by helping educators to find ways to integrate STEM in early childhood curricula, capitalising on a natural focus on arts in early childhood (Sharapan, 2012).

The arts have been included into STEM more recently as a missing element necessary to encourage children's creativity and interest in the STEM disciplines (Hunter-Doniger & Sydow, 2016). According to Jamil, Linder and Stegelin (2018), the world is full of endless possibilities and opportunities for young children, and through art and creative expression, they learn what works and what does not. In addition, the arts provide motivation and enhance memory systems, analytical skills and motor coordination (Sousa & Pilecki, 2013). Sousa and Pilecki (2013) referred to creativity, critical thinking, problem-solving, collaboration, communication, initiative and self-direction as the "twenty-first-century skills" which are needed by all students to become successful adults in the increasingly complex world driven by technology. These 21st Century Skills are utilised in

both sciences and arts as well as being sought-after skills in the modern job market (Pollman, 2017). In keeping with a view of the arts as an important addition to STEM disciplines, Root-Bernstein (2015) has reported that many scientists, specifically Nobel laureates in the sciences, are involved in some sort of artistry, be it poetry, painting or music.

STEAM research is still in its infancy (Bush & Cook, 2016), with much of the research to-date focusing on STEM education and with only a more recent integration of the arts in STEM research and education. In this literature review, we adopt the view of the arts as an important and integrated field within STEAM education rather than a useful adjunct to STEM disciplines. As research is nascent on STEAM as a fully integrated approach, it is important to note that much of the literature reviewed here refers to STEM learning as an integrated approach or as individual subjects (science, technology, education or mathematics). STEAM prepares students for their future careers by developing the aforementioned 21st-century skills. STEM and the arts complement each other, and as the workforce is expected to have characteristics of both, there is an onus on education systems to support STEAM learning (Oner et al, 2016). However, we note here the ongoing challenges as highlighted by others in understanding and implementing STEAM as a relatively new and integrated approach in early childhood education (Ng, Kewalramani, & Kidman, 2022)

For the purposes of this report, a flexible approach to the inclusion of relevant literature to either STEM or STEAM has been adopted for selecting and reviewing research. Where research only refers to STEM or to individual STEM subjects, we use the terminology used in the cited research. Thus literature is reviewed that refers to both an *integrated*

approach in early childhood education to teaching and learning in Science, Technology, Education (the Arts – where included) and Mathematic, and also to individual subjects where relevant to early STEAM learning.

Why Focus on STEAM Learning in Early Childhood?

Young children are naturally curious about the world around them. Young children's inquiries about natural phenomena suggest that they have a wide range of questions related to technology, physical science, life science, and Earth and space science (Patrick & Mantzicopoulos, 2015). Children ask many information-seeking questions, asking on average 76-95 per hour when in conversation with an adult (Chouinard, Harris & Maratsos, 2007). Children's interest in science and positive attitudes decline with age and by secondary school, it is much lower than in early childhood (Fredericks & Eccles, 2002). Despite this early interest in STEM concepts and experiences by children, girls and women are less likely to undertake STEM subjects and careers (The STEM Education Review Group, 2016). Investigating children's persistence in science play in early childhood classrooms, Gilligan and colleagues found gender differences in children's persistence in a digital science game (Gilligan et al., 2022), with boys significantly more likely to wish to keep playing the game than girls. The study focused on engagement in one 'sink or float' digital game and thus more research is required across STEM learning contexts to further investigate the extent whether gender differences are evident in early childhood STEM engagement (Gilligan et al., 2022).

Young children are very capable of learning and engaging in the practices of science, such as questioning, reasoning, inquiry, investigating and communicating (McCormick, Smith, & Chao, 2018). Children engage naturally in hands-on exploration and experimenting

within their natural environment. For example, the use of hands-on methods found in the arts to teach science, such as imaginative and multisensory approaches, have been found to attract and retain students in STEM fields (Bequette & Bequette, 2012).

Motivation to engage in STEM learning is an important predictor of attainment in STEM (Patrick et al., 2008). It is through systematic and rich experiences that motivational belief systems about science are constructed, organized, and maintained, including perceptions of self and science (Patrick et al., 2015). Parents play an especially important role in young children's early learning experiences due to time spent in close proximity at home, with parents playing a key role in answering questions and supporting children's learning in diverse ways during the time they spend outside of school (Hadini & Rood, 2018).

The educational provision of science, technology, engineering, and mathematics (STEM) disciplines has experienced an increased presence in government educational policy development internationally over the last decade (Wan et. al., 2021; Murphy et al., 2019). Irish educational policy, too, has witnessed an increasing focus on STEM education provision from early childhood to third level education, publishing focused policy documents and implementation plans for STEM education (DES, 2011; DES, 2017a; DES, 2017b; DES, 2020) across these educational sectors.

Young children's informal engagement with STEM activity is not new. Early childhood educators have traditionally valued and harnessed children's holistic exploration and inquiry of their world. Educational pioneers such as Pestalozzi, Froebel, and Montessori recognised children's natural curiosity and interest in their environments and included aspects of STEM education within their educational programmes (Bruce, 2021; Montessori, 1964). Dunphy (2012) identifies three contexts for early learning: (1) extended talk and discussion, (2) rich

imaginative experiences and (3) first-hand learning. Each of these contexts potentially offer authentic, relevant and meaningful opportunities for high-quality interactions that facilitate collaborative learning experiences via STEM processes such as observing, questioning, measuring, predicting, experimenting, analysing, problem-solving, creative and critical thinking and communication of ideas (NCCA, 2009; Yelland, 2021). More recently, DeJarnette (2018) noted that when young children are involved in hands-on STEAM activity, they are excited and enthused by the concepts conveyed to them in this active manner. Young children do not compartmentalise their world, their environments are seen as a whole, and as a result, the early childhood education tradition has always welcomed and valued an integrated approach to education.

During their primary school years, young children in Ireland experience an integrated approach to STEM education (Government of Ireland, 1999; Department of Education, 2020). The current primary school curriculum (GoI, 1999) states that elements of STEM are taught through the broad curriculum area, *Social, Environmental and Scientific Education* (SESE), an integration of science, history and geography, with mathematics being taught as a subject in its own right, as mathematics is viewed as being fundamental to all other STEM disciplines (DES 2017a). This pedagogical strategy particularly reflects the holistic nature of education in the early years of primary school, which is reflective of the inter-connected way in which young children view their worlds.

This integrated approach will be further embedded in future iterations of the curriculum. The draft revised primary school curriculum (currently under consultation) (NCCA, 2020) puts forward seven inter-linking key competencies, which link to the four themes of *Aistear,* the early childhood curriculum framework (NCCA, 2009), and which aim

to ‘extend beyond skills and knowledge’ (p.7). Aspects of STEM education are embedded within these key competencies: being a digital learner; being mathematical; communicating and using language; fostering wellbeing; learning to be a learner; being an active citizen and being creative. The redeveloped curriculum areas for early childhood primary classes will include: mathematics, science and technology education, arts education and social and environmental education with broad learning outcomes to support linkage and integration across curriculum areas (NCCA, 2020).

In addition to the primary school curriculum in Ireland, educational practice within the first two years of school is underpinned by *Aistear the early childhood curriculum framework*, Ireland’s curriculum framework for children aged 0- 6 years (NCCA, 2009). Under this framework, learning is framed under four themes: Well-being, Identity & Belonging, Communicating and Exploring and Thinking. Aistear advocates for a playful pedagogy and holistic, integrated learning experiences across the pre-school and primary school sectors, ensuring consistency in pedagogical approach and content explored in each setting.

While Aistear (NCCA, 2009) promotes young children’s active exploration of the world around them through STEM skills such as problem-solving, hypothesising, predicting, connection making, observing, and questioning, STEM education is still largely under developed in the Irish pre-school sector (DoE, 2020). Thus, although STEM education in early childhood education is increasingly visible in government policy development, a focus on early STEM learning is less evident in the research literature (Tippet & Milford, 2017).

Why Focus on Parents to Support Early STEAM Learning?

Both the primary school curriculum (GoI, 1999) and Aistear, the early childhood curriculum, (NCCA, 2009) identify parents as a child's first educator and endorse close positive, reciprocal, working partnerships with parents in supporting children as they learn and develop. Indeed, both documents position a child's learning as a continuous process between informal learning processes at home and the more formal learning processes at school.

Research shows that parental engagement in children's education, especially outside of school, has a positive effect on their learning (Crowley et al., 2001; Pattison & Dierking, 2019). Furthermore, active parental involvement has been shown to lead to learner success regardless of ethnicity, parent education or socioeconomic status (McClure et al., 2017; Cian, Dou, Castro, Palma-D'souza, & Martinez, 2022).

Early STEM experiences by young children have been shown to have a lasting impact on future STEM identity and career intentions (Cohen et al. 2021). Research shows that parents are enthusiastic to support their children's STEM learning (McClure et al., 2017; Pattison & Dierking, 2019) and that, although they often lack confidence in supporting their children's science learning (Gilligan et al., 2020), they are capable of using diverse strategies to support children's understanding of STEM concepts (Pattison & Dierking, 2019)

Such parent involvement in their child's learning outside of school has been shown to have a strong positive effect on children's involvement in STEM activities (Van Voorhis et al., 2013; National Science Teachers Association, 2009). As well as engaging in activities which can help their child to connect school and outside of school learning, parents can be supported to engage with their child in informal STEM learning experiences such as in libraries and museums. Parental conversations with children in active, hands-on, informal

spaces such as these, impacts children's learning of STEM concepts as well as their broader interest in STEM (Crowley et al., 2001; Callanan et al. 2017).

At home, children's play with parents in fun and engaging activities such as board games and block play, positively impacts children's STEM learning (Ramani & Siegler, 2008; Casey et al., 2018). Parents may also have a significant impact on children's motivation and achievement by actively supporting the development of a growth mindset in children: people with a growth mindset view effort as more important than a fixed or innate ability and it has been proposed that this mindset or approach to learning is a key attribute to successful engagement in STEM disciplines (Dweck, 2006; Dweck, 2008). There is also some evidence that parents' own beliefs play an important role in shaping their children's interests (Pattison, 2014; Pattison & Dierking, 2019).

Research consistently emphasises that adult guidance, support and awareness are critical to supporting children's STEM capacity (Hadani & Rood, 2018). Indeed, for some types of STEM learning for young children, research shows that adult support is essential. Learning approaches such as Guided Play in which the adult's presence and engagement with children through playful learning is essential has been shown to be highly effective for some types of STEM learning (Fisher, Hirsh-Pasek, Newcombe, & Golinkoff, 2013). In addition, it is recommended that when young children engage with digital technologies, they learn best through adult interaction, talk and support (NAEYC & Fred Rogers Centre, 2012). As there are so many opportunities for children to engage in STEM learning outside of school settings and for parents to support this learning, parental engagement in children's STEAM learning offers great potential for improving children's success in STEM.

Additional Considerations: Inclusive Early STEAM Learning

Marginalised communities tend to be underrepresented in STEM fields and careers (Rainey et al., 2018; Hassinger-Das et al., 2020; Roncoroni et al., 2021). The European Institute for Gender Equality (EIGE) defines marginalised groups as those at risk of multiple discrimination due to the interplay of differing characteristics such as sex, gender, age, ethnicity, religion, belief, health status, disability, sexual orientation, gender identity, education or income or geographic location. Belonging to such groups risks inequality in terms of access to rights and use of services, including education and employment (EIGE, 2016). There are many reasons for underrepresentation in STEM. Students may lack what is now seen as the STEM capital or resources required to succeed, which benefits some groups within society over others when it comes to STEM careers (Archer et al, 2010; Kane, 2016). Members of marginalised groups don't always fit into stereotyped STEM identities which have been described as "white, male, middle to upper class, English-speaking individuals" (p. 58, Cian et al., 2022), increasing the likelihood of being excluded from STEM environments (Avraamidou, 2019, Cian et al., 2022). In addition, those from marginalised groups may lack role models and representation within STEM courses and careers, leading to issues such as decreased motivation (Roncoroni et al., 2021) and feelings of not belonging, which in turn impact the likelihood of persistence and success in these fields. (Rainey et al., 2021).

In Ireland, there is limited research on STEM and STEAM for pupils from marginalised communities. However, there is a recognition in Education policy that students from DEIS (Delivering Equality of Opportunity in Schools) schools, are not performing as well in STEM subjects as their counterparts in non-DEIS schools (STEM Education Review Group, 2016). The Government's STEM Policy and Implementation Plan have both outlined explicit targets in order to try to improve the performance of students within DEIS schools by aiming to improve achievement in STEM disciplines, as well as increasing the uptake of STEM

related subjects (DES, 2017). Similar achievement gaps, beginning early and persisting, have been shown to exist for historically marginalised groups in other countries (Murphey et al., 2017).

Methodology

The literature review draws on systematic review methods to facilitate a robust and comprehensive overview of what is currently known about parental attitudes to and confidence in supporting young children's STEAM activities and learning at home, as well as an overview of effective interventions to enhance parental engagement in STEAM activities at home.

Search strings were developed to identify peer-reviewed studies published within the past 20 years relevant to each of our major research questions. Inclusion criteria for searches were that studies were published in English, in peer-reviewed journals, and included an early childhood education focus on any of the major disciplines in STEM or an integrated approach to these with or without an inclusion of the arts (studies of older children's learning in these disciplines were excluded). A decision to only include peer-reviewed outputs was made to ensure findings were robust and could reliably inform the development of educational resources for parents. EBSCO and SCOPUS databases were used for searches throughout the review process.

FINDINGS

1. Parental Attitudes to, and Confidence in, Supporting Early STEAM Learning

Parents have long been identified as children's first educators and consequently the home learning environment (HLE) is cited as being a site for early learning (Kewalramani,

Phillipson & Belford, 2022; Buek, 2019). The parent-child interactions that occur with the HLE, such as doing puzzles (Sun & Moreno, 2021), playing games (Zhang, Hu, Zou & Ren (2020), and house-hold chores are potential conduits for early STEAM education. While research exists on parental involvement in individual disciplines of STEM, with science (e.g. Gunning et al., 2016), technology (e.g. Farrugia & Busuttil, 2021; Davis, Harris, & Cunnigham, 2019), Engineering (e.g. Ata-Aktürk & Demircan, 2021; Marcus, Haden, & Uttal, 2016) and mathematics (e.g. Knapp et al., 2017; Perry et al., 2016), research is particularly lacking in the field of parental involvement in STEM as a meaningful, integrated learning experience for young children (Thomas et al. 2020; Marotto & Milner-Bolotin, 2018) with even less available on STEAM as an integrated approach for parents to support children's early learning.

Children's interests in STEM concepts form early (Clements & Sarama, 2021) and are susceptible to external influences such as parental views, beliefs and attitudes towards the STEM disciplines (Pattison & Dierking, 2018). Such affective characteristics can influence parental ideas about when STEM education should begin, and if and how STEM-related activity is carried out in the home. Reasons for levels of parental engagement in early STEM education are varied, and include beliefs, attitudes, values and content knowledge of STEM subject areas. These factors have been referred to in the literature as 'scientific capital' (Gerson, Morey, & van Schaik, 2022).

When parents are actively involved with their child's educational activities, such as homework, communicating with school or participating in school-based activities, children not only become better learners (Carmichael et al., 2013) they also develop confidence and display higher-levels of engagement (McClure et al., 2017). A longitudinal study of randomly

selected 196 5-year-old children and their parents, found that the frequency of informal math activities, including number game and application activities, was associated with formal math skill levels in preschool. Higher involvement in informal mathematical activities in the HLE during the preschool years significantly predicted the rate of growth in formal math skills through first grade (Zhang, Hu, Zou & Ren, 2020). While some studies report high levels of parental involvement in early STEAM learning, others suggest that there is huge variation in terms of willingness to participate in such activity (e.g. Davis et al., 2019). Findings from a small study conducted by Kristiana (2021) of three parents' engagement with home STEAM activity during the pandemic showed that participants did not generally engage their children in STEAM activity.

A recent report on STEM education in Ireland (DES, 2017b) noted that during focus group discussions, parents were positive about STEM education and understood the importance of developing skills such as critical thinking about the world. Parents also reported that they would like to see their children take part in extra-curricular STEM related activities (DES, 2017). Findings from this report are unclear however, in terms of extra-curricular STEM activities occurring in schools, as parent workshops for example, or elsewhere.

Gilligan et al. (2020) found wide agreement amongst parents of young children that science was both important and useful. In addition, 70% of parents in their survey believed that children should start learning science before the age of 4. Several studies have investigated parental attitudes to maths learning specifically. Galindo et al. (2019) reported that the majority of immigrant mothers in their study felt that parents and the home had an important role to play in their children's maths learning. Vasilyeva et al. (2018) found that

parents' valuing of maths for their children was directly related to the frequency of both formal and informal activities they engaged in with their children. They also noted that parents' beliefs about the importance of school preparation with their kindergarten children predicted their engagement in formal maths activities with their child but not informal activities. They proposed that parents needed to know that both formal and informal maths activities were important. Parents thus often value STEM subjects or STEAM learning and their role in their child's STEAM learning, indicating that, with effective supports, this value can translate into parents supporting their children's STEAM learning at home.

Parental preferences in favour of STEAM education can influence children's willingness to engage with or to study STEAM subjects such as science. Elliott and Bachman (2018) research found that when parents hold positive beliefs towards aspects of early learning, this leads to higher involvement in children's learning leading to positive educational outcomes even after controlling for SES. Findings from a UK Survey study of 729 parents of children 0-17 years, conducted by Gerson et al. (2022), showed that young children are outpacing parents at coding experience before 8 years of age. Findings suggested that parents who highly value STEM education were more likely to report children's experience with coding activity and that parental experience of coding positively influences children's engagement with coding.

While parents may hold the view that children's early engagement with science is valuable and that it should start early (Gilligan et al., 2020), research suggests that these views are not enough to facilitate parental involvement in early STEM learning. Other factors include level of scientific knowledge and confidence/ self-efficacy impact on informal engagement with STEM education within children's home learning environments (HLEs).

Yamamoto's (2015) exploration of Japanese mothers' views of academic achievement showed that there was a perception among low-income mothers that more affluent mothers were better placed to support their child's academic achievement generally, both in terms of personal subject knowledge and the ability to fund extra learning activities (higher science capital). Mothers who stated that once they felt they could not support their children's learning due to lack of relevant knowledge, withdrew from the support process and that this was often a source of anxiety and stress. This longitudinal study found that by second grade, low income mothers were more likely to report that their children had acquired negative dispositions towards learning. These findings are supported elsewhere in the literature: parents who feel they lack the necessary content knowledge in STEM related topics/subjects and therefore, avoid engaging with STEM learning outside of school (Barrett, 2017; Knapp et al. 2017).

Guo, Piasta & Bowles' (2015) study of 194 preschool children's science knowledge found that children whose mothers had a Bachelor's degree or higher demonstrated higher levels of scientific understanding than children whose mothers had lower levels of education. These findings are echoed by Tippet & Milford (2017) whose study of STEM education in the pre-kindergarten classroom of a Canadian private school, found that parents could speak about STEM topics at length. However, parents still wished to learn about strategies for engaging their children in STEM topics outside of the classroom.

Wilder's (2017) study of parents from kindergarten children to grade 2 in the US in relation to mathematics learning demonstrated that parental self-efficacy in mathematics education was high for parents of children in grades K to 2 but dropped in grade 3. Findings indicate that not only do parents of Kindergarteners feel more comfortable with helping

their children with mathematics, mothers of Kindergarteners also willing to share responsibility for their child's mathematics learning with their teacher. Findings from Pattison & Dierking's (2018) study of eight four-year-old girls and their mothers highlight the importance of triggering or stimulating interest in STEM, specifically scientific, concepts among children (girls) and parents in early childhood. The mother-daughter dyads were provided with a number of science activities and resources to engage with. Findings showed that not only did sustained interest in some scientific areas occur, an interest in engaging with scientific processes was also observed, as both children and parents interacted with the resources and activities.

Eason & Ramani (2020) found that parents rated guided play maths activities as being more enjoyable than formal maths activities. They recommended that guided play activities should be favoured when children and parents engage in maths activities together, so as to offer enjoyment and fun when learning, which in turn could help to develop positive maths attitudes. Galindo et al. (2019) reported that approximately half of the mothers in their study enjoyed maths and felt they were good at maths. They recommended that supporting mothers to feel positively towards maths could empower them to support their child's learning.

Raynal et al. (2021) reported that parents expressed confidence in science and supporting science learning for their children but that this confidence decreased when the parents were actually engaged in learning sessions with their children. Research by Gilligan et al. (2020) showed that the parents in their survey were actively engaged in supporting their children's science learning. However, just under half of parents expressed some lack of confidence when talking about or doing science with their children with mothers significantly

less confident in talking about science with their children than fathers. Mothers' lack of confidence in talking about science was associated with reduced frequency of engagement in science activities.

Parents' own maths attitudes have predicted children's maths attitudes and achievements, most likely through parents' behaviours (Levine & Pantoja, 2021). Research by Vasilyeva et al. (2018) showed that parental math self-efficacy predicted the frequency of informal, but not formal, activities they engaged in with their kindergarten children. Similarly, Hightower et al. (2021) reported that parental self-efficacy in informal maths and science was a positive predictor of the number of informal science and maths activities they did with their children, including the use of science media. Clements (2021) also suggested that parental math anxiety could be the reason for the lack of number talk by all parents in their study, irrespective of parental education. It may be that parents are more likely to support children's learning for science subjects that are easier to understand or have an influence on their daily lives (Çobanoğlu & Yurttaş-Kumlu, 2020). However, parents' motivation to engage children in science and maths learning has been shown to be high irrespective of parental perceptions of their own abilities in science and maths (Hightower, 2021).

Overall the research indicates that increasing parents' enjoyment, confidence and self-efficacy in STEAM subjects is vital to increasing their engagement with young children to improve their STEAM learning. Gender and SES are also key characteristics to consider in understanding parental attitudes to, and confidence in, engaging in STEAM activities with young children. review revealed differences in how parents supported their children's STEAM learning according to the child's gender. From as young as 18 months old, mothers make twice as many verbal maths references to boys as to girls, showing that such differences begin very

early (Leech et al., 2021). Levine & Pantoja (2021) have found that parents' math-gender stereotypes predicted a belief in greater maths ability for sons than daughters, and predicted different maths interactions between parents of boys compared to girls.

Elliott & Bachman (2018) have found positive associations between parents' high expectations for their children's learning and children's maths outcomes. Levine & Pantoja (2021) found that parents with high maths anxiety have lower expectations and value for their own child's maths achievements but that these expectations and values are malleable. They suggest that improving child-parent maths interactions through engaging in maths activities that are fun, process-focussed and which build Maths skills could improve parents' expectations and value for their own child's maths achievements. This in turn could improve children's maths learning.

In summary, educating parents around the importance of STEAM learning for both boys and girls is an important consideration when supporting children's early STEAM learning. In addition, supporting parents to value and also, increase their expectations of their children's STEAM achievements, possibly through informal and playful STEAM activities, could support children's STEAM learning.

2. Educational Approaches that Support Parental Engagement in Early STEAM learning

Published studies on interventions to support integrated STEM learning are limited with most studies focusing on the individual disciplines of STEM education. Research indicates that parents are more comfortable engaging their children in STEAM activity when they receive information/instructions about how to facilitate STEAM learning with every-day objects and activities and incorporate children's interests. However, the ways in which information is given to parents appears to be a critical factor in determining their

engagement with STEM activity in the home. Parents favour information presented in a hard-copy format, such as a subject specific guide for learning at home made by the child's teacher (Kristiana, 2021). In Kristiana's (2021) study, the teacher produced booklet, with lesson objectives, activity plans and a place to record work done was greatly valued by parents. The booklet facilitated high levels of parental engagement with both the suggested STEAM activities and recording of child learning. An evaluative study of an intervention to engage 56 parents in STEM activity in the home by Barrett (2017) found that provision of a toolkit, coupled with access to a mentor led to high levels of parental engagement with STEM activity. This intervention focused on increasing levels of STEM talk in the home. In addition to the toolkit parents also had access to a monthly blog. Post study meetings revealed that parents valued the use of similar resources used by teachers as this was seen to lend consistency between home and school STEM activity. However, parents commented on the need for direct assistance in delivering the prepared activities at home. Recommendations arising from this research included that schools include parents in STEM activity through the sharing of resources.

It should be noted that in this study, parents felt they would benefit from more direct assistance in providing STEM experiences at home, and that access to a mentor was highly valued by participants. Similar findings (e.g. Kristiana, 2021; Marcus et al. 2018) suggest that providing parents with instructions for completing STEAM related (engineering) activity results in higher rates of conversation on scientific processes with young children (4-6 year olds), and in questioning more generally. Knapp et al.'s (2017) study of 45 low-income parents' engagement with a mathematics course produced comparable findings. Knapp et al. (2017) showed higher levels of parent-child interaction in mathematical activity at home and levels of mathematical knowledge among parent participants as a result of

taking part in the mathematics course alongside student teachers. Both studies show that when provided with training and materials, in conjunction with teacher collaboration, parental knowledge, interest and self-efficacy improve.

Perry et al. (2016) adopted a community-based approach to enhancing mathematics learning and dispositions in 4-5 year olds and their families in designated disadvantaged areas in Australia. The *Let's Count Program* (2016) focused on professional learning for early childhood educators, not only in key mathematical concepts and pedagogy, but also in how to develop strong partnerships with parents. Educators were encouraged to help parents to notice, explore and talk about mathematics with their children in their environments. Results from the pilot study indicated that the programme assisted both educators and parents to enhance children's mathematical engagement, learning outcomes and dispositions towards mathematics. Educators reported a positive impact on self-confidence and on practice around mathematics after engaging with the programme. Other positive impacts of engagement with the programme included older siblings being included in mathematical activities at home. An increase in the use of mathematical language was noted both in the preschool and home settings.

Marcus et al.'s (2018) engineering-focussed study, provided families of 4-8 year-old children with a set of instructions on building and stabilising a skyscraper in a museum setting. Findings from this study showed that parents of younger children talked more about science processes, technology & engineering ***but not*** mathematics, suggesting that generally parents were able to scaffold younger children's STEM knowledge acquisition. However, parents who received both engineering and transfer instructions talked more about mathematics then those who did not receive any instructions, indicating that when provided

with both instructions as to how to complete an activity coupled with instructions as to how to apply knowledge to different problem-solving situations, STEM talk increased between parent and child.

In science and engineering, Gunning et al.'s (2016) intervention study with families from low SES and second language backgrounds, showed that initially children found it hard to articulate what science is and found it hard to describe scientific activities. This was attributed to two possible scenarios; one, that this may be due to lack of parental labelling of the activities as being scientific in nature or that the children had not yet experienced science activities in school (Gunning, Marerro, & Morell, 2016). Families engaged in two workshop sessions in science activity and were provided with a *Science Bag,* containing a notebook and some scientific tools to enable families to carry out extension activities based on the sessions. Between each session, children recorded evidence of stimulus and response of animals in locality in the provided notebooks. As a result of engagement with the first session, families participated in high levels of observation and recording of animal behaviour in the local environment. A review of the intervention a year later showed that engagement with these processes of observation and recording was still high and that enthusiasm and use of the *Science Bags* was maintained. There was also evidence to suggest that the use of science vocabulary increased in some households. Gunning et al. (2016) noted however, that parents needed greater guidance than was initially anticipated in facilitating science activity and learning. This element was included in the second session. Parental self-efficacy in engaging with science activity with their children improved after the two sessions and was observed a year later with follow-up focus groups

A common finding was that in order for such initiatives to work, communication between educational setting and the Home Learning Environment must be established. As Donohue (2020) notes “high quality STEM learning requires parents and educators to play an active role as STEM learning companions and mentors” (p.15). Jay et al.’s (2018) research with parents in sixteen primary schools in England, showed that parents were dissatisfied with the level of communication between home and school, stating they would like more information on curriculum content. (Marotto & Milner-Bolotin, 2018) maintain that connection and communication between home and school is critical for parental learning about curriculum requirements. Findings from Thomas et al.’s (2020) study suggest that sending home detailed guidance, linked to curricula, as well as providing relevant resources/equipment is extremely effective in strengthening interactions between child and parent in STEM related learning. However, Marotto, & Milner-Bolotin (2018) note that referring parents to online versions of curriculum documents is not looked upon favourably by parents.

Conclusion

This review highlights that while there is a growing emphasis on STEAM in educational policy, including early childhood education, research literature on early STEAM interventions for parents is limited, with literature on STEAM as an integrated approach to learning particularly new and emergent. However, this review highlights extensive research on the importance of parental input in supporting young children’s early STEAM learning and engagement. A growing body of research shows the importance not only of how parents value early STEAM learning but also how confident and capable parents feel about their own knowledge and capacity for STEAM activities with young children. There is

evidence of differences in parental confidence and self-efficacy both by parents' level of education and also by parental gender, with mothers significantly more likely to report lower levels of confidence, and parents with less formal education significantly more likely to report less engagement in early STEAM activities. In addition to considering parental characteristics in developing educational resources for STEAM engagement and learning, the research reviewed here highlights the importance of providing guidance and resources for parents to support STEAM activities at home, and that parents value communication from schools on curriculum content specifically.

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