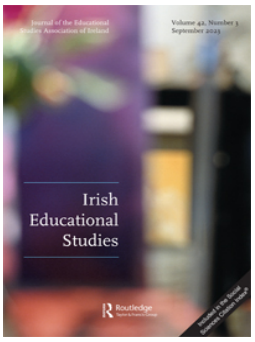

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Hungry for more: early childhood educators' perspectives on STEM education, teaching and professional development

Sandra O'Neill, Córa Gillic & Nicola O'Reilly

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Hungry for more: early childhood educators' perspectives on STEM education, teaching and professional development

Sandra O'Neill, Córa Gillic and Nicola O'Reilly

Institute of Education, Dublin City University, Dublin, Ireland

ABSTRACT

Increasingly, educational policies and curricula recommend that young children experience STEM learning opportunities within Early Childhood (EC) settings. Despite greater demands placed on EC educators, their opinions on STEM have seldom been sought. This study investigated EC educators' (1) interest in STEM education (2) opinions about the appropriateness of EC STEM education (3) ratings of their STEM self-efficacy and (4) STEM professional development preferences. An anonymous online questionnaire was distributed in the Republic of Ireland, with 198 complete responses received. The respondents, many of whom were highly qualified and experienced educators, reported being interested in STEM and felt it was important, though notably, some believed only for older children. Two-thirds felt their preservice education, which included mathematics (43%); science (30%); technology (17%); and engineering (10%), had not prepared them to support STEM. Knowledge of STEM policy was also limited. Despite this, high levels of STEM confidence were reported. Challenges reported included a lack of resources, support and guidance, and STEM knowledge. 96% of respondents expressed interest in attending EC STEM professional development and a variety of approaches to learning were identified. Implications for policy and practice are suggested.

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STEM; early childhood; professional development; early STEM teaching; STEM education

Introduction

With an increased focus on Science, Technology, Engineering and Mathematics (STEM) education globally, and a growing interest in STEM education from children's earliest years, this paper reports on perspectives of Early Childhood (EC) educators on STEM education in the Republic of Ireland (RoI). STEM education is described as the teaching of science, technology, engineering and mathematics in isolation, or with a cross-disciplinary approach, which builds on content knowledge and understanding across each discipline (GoI 2023). There is often explicit recognition of the need for STEM education

CONTACT Córa Gillic cora.gillic@dcu.ie Institute of Education, Dublin City University, St Patrick's Campus, Dublin 9, Ireland

to begin in Early Childhood Education (ECE), using play and exploration to support the development of curiosity, critical-thinking and problem-solving capacities (DES 2017a). There is also evidence of strong parental support for STEM education to begin in the preschool years (Gilligan et al. 2020). Most research on EC STEM education in RoI however, relates to the views of primary school teachers (Hourigan et al. 2022). Consequently, little is known about the views of educators working with children from birth to 6 years, in settings prior to compulsory education. Given that this is the foundational phase of the Irish educational system and settings are now inspected using STEM criteria (DoE 2022a), there is a need to ascertain the views of these educators. Important questions, such as those around pedagogy, are often eclipsed by debate around the economics of EC educational provision (Smyth 2022). This study aims to engage the voices of EC educators in trying to answer these other kinds of questions.

Research questions guiding the study are as follows; what interest do EC educators have in STEM education? Do they consider it appropriate? How do they rate their STEM self-efficacy? And what EC STEM education or professional development (PD) have they participated in? The study sought to gain a greater understanding of the sector's awareness of their obligations to support STEM education, the challenges they face in providing EC STEM and the extent to which their initial education has prepared them. International educational policy makers increasingly emphasise the need for STEM education within the sphere of EC (Wan, Jiang, and Zhan 2021), but there remains a paucity of empirical research in this field (Tippett and Milford 2017; Wan, Jiang, and Zhan 2021). It is important, therefore, to understand the beliefs and values that EC educators hold towards early STEM learning, and to ascertain their professional development interests and needs. While some of this information is available for other countries (for example, see Nikolopoulou and Gialamas 2015a, 2015b; Park et al. 2017; Pendergast, Garvis, and Keogh 2011; Vidal-Hall, Flewitt, and Wyse 2020), to date this data has not been gathered in the RoI.

Irish policy context

Over the last 10 years, an increased Government focus on early childhood STEM education has emerged (DES 2017a, 2017b, 2020b, GoI 2023; STEM Education Group, 2016), with the aim that 'STEM education will be an integral part of the culture, policy and practice of our early years settings' (DES 2017a, 13). Provision of STEM learning opportunities within ECE in the RoI has been deemed poor (DES 2020b). The STEM Education Policy Statement (DES 2017a) and accompanying STEM education implementation plans (DES 2017b; GoI 2023) work towards adapting the entire education system to prioritise the teaching and learning of STEM subjects. The current iteration of the national STEM implementation plan (GoI 2023) acknowledges that foundational STEM learning occurs within EC settings, and is experienced through a hands-on, active, playful learning approach. Further, it positions EC educators in the valuable role of developing critical STEM skills and dispositions and openly recognises the need for resources and support to help them engage in this work. Plans are in place to develop STEM PD for educators, initiate communities of practice, and revise the national EC curriculum framework (see GoI 2023 for details). However, to date, limited supports have been provided (DoE 2022b).

According to the Department of Education themselves, (DES 2020b), few EC educators are aware of their obligations under the STEM Education Policy Statement (DES 2017a) to provide learning opportunities for young children in this area of education. Many educators report that their initial education has not prepared them to teach STEM subjects (DES 2016) and are unsure what methods or materials are appropriate for use with children from birth to six years (DES 2020b). Historical qualification requirements meant that few pre-service EC courses included STEM education, and despite government plans (DES 2017b), few opportunities exist for in-service educators to upskill in this increasingly important component of ECE. More recently, STEM discourse has influenced education policy in RoI, leading to changes to pre-service training requirements, inspection and policy documents. Recent changes to the QQI Award Descriptors for accredited programmes include reference to supporting young childrens' 'emergent digital literacy, numeracy, creativity, problem-solving and STEAM skills' (QQI 2019, 6). Those delivering pre-service training at the degree level are required to develop EC trainees 'knowledge of children's different strategies of learning; play-based, social learning, early literacy and numeracy, language acquisition and multilingualism' (DES 2019, 16). The recent update of the *Workforce Development Plan* for the early childhood sector outlines that EC educators at all levels should be able to 'to support children's emergent language, literacy, (including digital literacy), numeracy, creativity, early science, technology engineering, arts and mathematics' (GOI 2022, 122). In addition, the Department of Education's Early Years Inspection Tool (DoE 2022a) includes explicit criteria related to the development of STEM dispositions, requiring settings to demonstrate their practice in this area.

This influence can also be seen in changes to key EC policy documents. A revision of Aistear, the national curriculum framework (NCCA 2009), is underway and a literature review was carried out to support its revision (see French and McKenna 2023). It recommends reviewing Aistear by including STEM learning experiences; fostering key dispositions for STEM, such as curiosity, perseverance, resilience and problem-solving; and a focus on STEM-related pedagogy (Gillic, McKenna, and O'Neill 2022). The most recent STEM Implementation Plan mirrors this suggestion, stating that the 'updated Aistear will support opportunities for STEM learning through play and play pedagogy' (GoI 2023, 21). Similarly, 2023 saw the publication of *Towards a New Literacy, Numeracy and Digital Literacy Strategy: A Review of the Literature* (Kennedy et al. 2023) which places a stronger emphasis on STEM in EC. As part of this literature review, O'Neill, Gillic, and Kingston (2023) recommend the compulsory inclusion of mathematics content in preservice education from foundational EC qualifications to degree level. All of this indicates that, moving forward, STEM will remain at the forefront of the EC policy agenda for years to come.

Literature review

STEM in early childhood education

Situated within the context of real-world learning experiences, STEM is an integrated approach to learning, applying scientific, technological, engineering and mathematical concepts to projects in a holistic way (Katz 2010). Interdisciplinary connections between STEM disciplines lend themselves to the integrated and holistic approaches adopted in EC settings (Blum-Ross, Kumpulainen, and Marsh 2020). Traditionally, EC programmes have embraced children's holistic exploration and inquiry. Early advocates for EC education, such as Pestalozzi, Froebel, and Montessori, understood children's innate curiosity and interest in their environments and incorporated elements of STEM education within their programmes to harness these developing interests and learning dispositions (Bruce 2021; Montessori 1964). Children's earliest years see the development of 'natural dispositions to be intellectually curious and to investigate their environments' (Helm and Katz 2010, 18). Early STEM experiences have the potential to enable high-quality interactions such as sustained shared thinking and open-ended questioning (McClure et al. 2017; Marsh et al. 2019). When young children are engaged in hands-on STEM activity, they become excited and enthusiastic to engage with concepts conveyed to them in this developmentally appropriate manner (DeJarnette 2018). Young children view their environments as an integrated whole, and therefore, the ECE tradition has always held an integrated approach in high regard.

Moore et al.'s (2014) *STEM Integration Framework* offers six tenets for ensuring a quality STEM education from early childhood through primary education: (a) the inclusion of math and science content, (b) a child-centred pedagogy, (c) situating lessons in an engaging and motivating context, (d) inclusion of engineering design or redesign challenge, (e) students learning from mistakes, and (f) teamwork. Play as a pedagogical approach is integral to EC learning and development (Dunphy 2012; Wood and Hedges 2016) and not surprisingly, has been identified as a natural site for early STEM learning (Moomaw 2012). Indeed, young children's construction play, for example, often includes many of the six tenets outlined above as children are self-motivated to design, build and modify aspects of their constructions, work as a team to problem-solve and draw on mathematical (shape, space, number) knowledge as they position/reposition blocks in their creations (Van Meeteren 2015). Children's freely chosen play also offers opportunities to develop other skills associated with STEM education such as perseverance, creativity, divergent and critical thinking, as well as resilience (Simoncini and Lasen 2018; Tippett and Milford 2017). However, in order to recognise, enhance and celebrate early STEM learning, EC educators need to be willing to notice the STEM elements in play and this often depends on their personal beliefs towards the inclusion of STEM activity in EC settings.

Educator beliefs towards EC STEM

Jamil, Linder, and Stegelin (2018) contend that to develop methods of PD in growing fields such as EC STEM Education, it is necessary to gain a more comprehensive understanding of EC educators' beliefs and practices. Beliefs, attitudes and negative experiences impact how educators engage or do not engage with STEM in EC (Chen et al. 2014; Tao 2019) and can impact, either positively or negatively, on the learning experiences that children receive (Saçkes et al. 2011). In tandem with subject content knowledge and pedagogical content knowledge, educator beliefs have been identified as a critical component of competence more broadly (Dunekacke et al. 2016). Defined as, 'tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught' (Kagan 1992, 65), beliefs can influence pedagogical practice (Chen et al. 2014; Fives and Beuhl 2016), impact daily decisions (Anders and Rossbach 2015), affect curriculum implementation (Platas 2015) and may also impinge on their ability to see STEM concepts in children's play (Opperman, Anders, and Hachfeld 2016).

Attitudes, beliefs and confidence are impacted by lack of exposure to STEM concepts, limited preparation on preservice courses and educators' own educational experience with STEM disciplines (Beilock et al. 2010; Lange et al. 2021). EC educators lack sufficiently detailed subject content knowledge of each of the STEM disciplines, as well as knowledge of how to integrate them into a STEM learning experience. This can be attributed to inadequate pre-service preparation (Al Salami, Makela, and de Miranda 2017). McClure et al. (2017) propose that EC educators should possess an understanding of the learning trajectories, or the progression paths children take when learning STEM topics. Learning trajectories comprise of three main elements: a learning goal (i.e. the STEM content), the developmental pathway that enables children to reach that goal (i.e. a sequence of levels of thinking), and the guiding activities and pedagogical approaches to support progression (Clements and Sarama 2016; McClure et al. 2017). With this knowledge, they are in a much stronger position to support STEM in EC settings.

Educators play a critical role in the development of young children's STEM interest. Early exposure to STEM concepts and processes can have a positive impact on children's learning and can lay the foundation for success in later schooling (Duncan et al. 2007; Morgan et al. 2016). However, many EC educators are not prepared or enthusiastic to provide rich experiences in domains other than literacy (Brenneman, Stevenson-Boyd, and Frede 2009: Clements and Sarama 2014; Duschl, Schweingruber, and Shouse 2007) or social and emotional development (Simoncini and Lasen 2018). With regards to the pedagogical approach, Schriever, Simon, and Donnison's (2020) study showed that EC educators position themselves as the 'guardians of play' and demonstrate a preference to align with and maintain the traditional play-based pedagogical approaches. EC educators view plans to teach mathematics as a threat to the traditional child-led, play-based learning approach as a path towards 'schoolification' (Fosse et al. 2018) for young children 'at the expense of play and engagement in nurturing relationships' (Shuey and Kankaraš 2018, 14).

Some EC educators possess positive dispositions towards the inclusion of STEM activity in EC classrooms, believing that an integrated STEM educational approach aligns with the much-valued play-based, child-led, pedagogy (Tippett and Milford 2017), and it is an appropriate pedagogical approach for young children (MacDonald et al. 2021), as well as being a critical part of an EC childhood curriculum (Park et al. 2017). Despite this positive outlook held by some educators, it is worth noting that 30% of the participants in Park et al.'s (2017) study felt that STEM was neither important nor appropriate for ECE.

Self-efficacy

Chen, Huang, and Wu (2021) define STEM self-efficacy beliefs as, 'the extent to which a teacher feels capable of teaching STEM to preschool children' (138). Both Morris, Usher, and Chen (2017) and Chen, Huang, and Wu (2021) suggest that a key relationship exists between an educator's pedagogical beliefs and their self-efficacy beliefs. Factors that influence pedagogical and self-efficacy beliefs are varied, and include previous education, professional experience, and personal and professional values (Fenty and McKendry Anderson 2014), as well as personal interest in the content being taught (Chen, Huang, and Wu 2021; Kim et al. 2015). Low levels of self-efficacy, coupled with low levels of self-confidence in relation to engaging with early STEM education have been noted with EC educators (DeJarnette 2018; Edwards and Loveridge 2011; DES, 2020a, 2020b). Once established, self-efficacy beliefs can be hard to change (Bandura 1997). Uncertainty around how STEM is conceptualised (Moore, Johnston, and Glancy 2020) or defined (Hourigan et al. 2022) can lead to an increase in formal teaching of STEM subjects rather than the integrated play-based pedagogy associated with ECE practice. Viewing integrated STEM as both a curriculum and a pedagogy (Margot and Kettler 2019) can help EC educators to align the integrated STEM approach to learning and development, and traditional beliefs as to how young children learn. Interestingly, some research shows (Jamil, Linder, and Stegelin 2018) that more experienced educators are more disposed to closely align themselves with, value, and understand the principles of STEM education than those who are less experienced. Jamil, Linder, and Stegelin (2018) posit that this difference in pedagogical belief may result from educator perception of STEM education as an 'add on' (415) rather than a pedagogical approach to achieve curricular demands among less experienced educators.

In terms of content and pedagogical knowledge, some EC educators report possessing adequate knowledge to engage young children in early mathematics education, however, they lack the depth of knowledge required to engage young children in engineering, science and technology (MacDonald et al. 2021). However, the MacDonald et al. (2021) study reports that STEM PD can strengthen both the content and pedagogical content knowledge of educators. Research shows that in order to successfully support children's STEM learning, EC educators require PD in STEM including; practical STEM experiences; guidance around effective STEM pedagogical approaches; as well as support to incorporate these into their EC settings (Aldemir and Kermani 2017; Brenneman, Lange, and Nayfield 2019). They also need to be able to identify the STEM experiences already happening in their classroom and understand exactly which STEM foundations are currently being supported in their setting. Such training can support educators to meet ever-increasing STEM policy requirements and, according to Watts and Salehjee (2020) understand that becoming STEM literate is a long-term process of engaging with, and developing an interest in, STEM.

Professional development (PD)

Professional learning interventions have been shown to not only positively impact EC educators' STEM practice, attitudes, beliefs, and confidence towards teaching STEM (DeJarnette 2018; John et al. 2018) but also result in significant increases in both pedagogical and content knowledge related to teaching STEM (Lange et al. 2021; Nadelson et al. 2013). This is positive, as a major 'stumbling block' in EC STEM implementation is educators' lack of knowledge (Stephenson et al. 2021). Furthermore, an absence of STEM knowledge due to a lack of PD results in low levels of self-efficacy when implementing STEM activities in the early childhood classroom (Park et al. 2017).

Characteristics of effective PD include, a research-based PD programme, delivered over time and incorporating hands on experience (DeJarnette 2018), observation, appropriate pedagogical strategies and access to a mentor (Brenneman, Lange, and Nayfield 2019). Websites with recorded materials are also considered effective, particularly post-PD programmes (Buchter et al. 2017). This is confirmed by a PD model for STEAM education in preschool settings, with a focus on Dual Language Learners, developed by Brenneman, Lange, and Nayfield (2019). This PD model comprised of a series of sequential 4 whole-day workshops, which were supplemented by a series of reflective coaching cycles within professional learning communities. Brenneman, Lange, and Nayfield (2019) concluded that the sustained nature of the programme, particularly the ongoing collaborative and supportive nature of facilitated professional learning communities, was more successful in terms of long-term commitment to early STEM education than shorter one-off workshop-type PD programmes, which often (due to the time-bound nature of the workshop) only 'skim the surface of the topic and its application to practice' (20). Curiously, research (Bautista 2011; Chen, Huang, and Wu 2021) suggests that educators who choose to engage with PD generally possess high levels of self-efficacy to begin with and their positive disposition towards early STEM education acts as a motivator for improving practice and the setting of high personal teaching and learning goals for themselves.

Challenges

A meta-analysis of studies in relation to early STEM education (Wan, Jiang, and Zhan 2021), showed that factors negatively impacting on successful implementation of STEM in early childhood classrooms included lack of time (Jamil, Linder, and Stegelin 2018; Park et al. 2017), lack of materials/resources (Jamil, Linder, and Stegelin 2018; Park et al. 2017) and administrative support (funding) (Jamil, Linder, and Stegelin 2018). Concerns relating to catering for children with additional needs and behaviour management, as well as potential health and safety issues were also reported (e.g. Jamil, Linder, and Stegelin 2018). Furthermore, beliefs at the management level favouring early literacy development, can influence the inclusion of STEM activity at the local setting/classroom level (Park et al. 2017).

Methodology

Using a qualitative interpretive research paradigm (Denzin and Lincoln 2018), an anonymous online questionnaire was used to gather data. This method was chosen as large amounts of data are collected economically and efficiently in a short time frame (Kelly, Sharpe, and Fotou 2022; Regmi et al. 2016) and are effective in gaining responses from typically 'hard to reach' participants (Andrews, Nonnecke, and Preece 2010; Braun et al. 2021; Regmi et al. 2016). Questionnaires provide descriptive, inferential and explanatory information and can be processed statistically making this process less time-consuming (Cohen, Manion, and Morrison 2018). The survey questions evolved from a brainstormed list created by the researchers and included the development of both closed and open-ended questions. The closed questions allowed for easier responses for participants, whilst the open-ended questions allowed participants to expand on, or explain their answers further. This provided an opportunity for participants to have their voices heard and ensure their point of view was reflected, by grounding findings in their experiences (Wisdom and Creswell 2013). Questionnaire design guidelines (Braun et al. 2021; Braun and Clarke 2013) were followed, to ensure that questions were both effective in answering the research questions and avoided bias.

Participants were EC educators working in settings for children from birth to 6 years in the RoI. Respondents working as primary school teachers were removed from the study as a different curriculum and qualifications requirement exist. All participants were at least 18 years of age and held an EC education qualification or were currently studying for one. An asynchronous online questionnaire was chosen, to enable participants to complete it at a time and place that suited them (Braun et al. 2021; Denzin and Lincoln 2018; Lefever, Dal, and Matthiasdottir 2007). This was deemed important by the researchers, for what they knew to be an often time-poor and busy cohort (Braun et al. 2021). A research invite was designed outlining key details of the study, including aims, information about the research team and how to access further details and/or take part. Prospective participants were contacted through 25 EC organisations in RoI, to achieve a high geographic spread and reach the widest group of participants as possible, at different stages of their career. Some organisations shared the research invite via their social media pages, while others emailed an invitation to participate directly to members. Research study investigators also shared this invite via their personal social media accounts. The proposed sample size was 300, as this is approximately 10% of the overall workforce in RoI, and the final number of questionnaires returned was 264. This figure was reduced to 198 complete responses that met all criteria.

Ethical approval was sought and granted from a higher education institute in the RoI. A plain language statement detailing information about the study, intended research outputs and potential risks was provided. Attention was placed on ensuring participants fully understood the aims of the study, how their data would be used, analysed and destroyed, and providing informed consent. As the study was anonymous, participants were informed that once submitted, their contribution could not be retrieved/removed. Participants granted consent online before completing the questionnaire. The assumption is that when a participant signs the consent form, they fully understand and accept the information therein (Mukherji and Albon 2018).

The online questionnaire consisted of 24 items to assess the following four areas: (1) participants' interest in STEM education, (2) participants' opinions about the appropriateness of STEM education in EC, (3) participants' ratings of their STEM self-efficacy and (4) participants' preferences regarding EC STEM PD. The majority of questions used a Likert scale to gather participants' degree of agreement or disagreement. The remainder of the questions were open-ended in nature. The design of the tool allowed for comparable data to be generated, whilst open-ended questions garnered qualitative data, identifying and describing elements that were of importance to participants (Cohen, Manion, and Morrison 2018). Data was gathered via the Qualtrics platform. This software allows for the collection, cleaning and analysis of data. Responses were removed if they were incomplete, if respondents were not working in EC or if consent was not granted. Answers to open-ended questions were analysed thematically using Braun and Clarke's 6-step Thematic Analysis Framework (2006). Using this frame, open-ended answers were read several times, and through an iterative process, initial themes were identified, defined and labelled by the research team, before being reviewed and refined.

Findings

Participant profile

Two-thirds of respondents were in full-time positions and had a minimum of 10 years' experience. The majority (67%) of respondents possessed a degree, while 17% had a level 6 qualification which is the minimum requirement for those in supervision roles in ECE in RoI. Relatively few responses were received from those on either end of the qualification spectrum; those with doctorates accounted for 1% of the group, 14% held masters qualifications, and those with a certificate, the minimum qualification requirement in RoI, accounted for just 3%. The most common role descriptors were manager or owner/ manager (42%), early educator (32%) and room supervisor (13%). The remaining respondents (approx. 15%) listed a variety of roles described further in Table 1.

Interest in EC STEM

When asked to rate their level of interest in STEM education, most were interested (36%) or extremely interested (44%). Only one respondent declared they had no interest at all in STEM. Similarly, many respondents stated that STEM was an important (34%) or extremely important (56%) element of EC curricula. One person felt it was not important at all and the remainder felt it was somewhat important (9%). Respondents' perception of how appropriate EC STEM is, appears to be affected by the age of the children being discussed. While low, the number of people stating STEM 'is not appropriate at all' was higher for babies at 5.59%, reducing to 1.86% for toddlers and further again for preschoolers at 0.62%. Moreover, there was far less consistency in responses when referring to babies (birth to 18 months) with variance in answers of 0.83. While the majority felt it was appropriate (33.54%) or extremely appropriate (34.78%) to support STEM with babies, almost a third held contrary positions stating it was not appropriate at all (5.59%) or somewhat appropriate (26.09%). By comparison, when considering preschool children

Table 1. Participant profile information.

Qualifications			
Qualification descriptor	Qualification level (RoI QQI framework)	Number of respondents ($N = 198$)	% figure
Doctorate	10	$n = 2$	1.01%
Masters degree	9	$n = 27$	13.64%
Honours degree	8	$n = 84$	42.24%
Ordinary degree	7	$n = 46$	23.23%
Diploma	6 (minimum criteria for an EC manager)	$n = 33$	16.67%
Certificate	5 (minimum criteria)	$n = 6$	3.03%
Role descriptors			
Role title	**Descriptors**	**Number of respondents ($N = 197$)**	**% figure**
Early educator		$n = 78$	31.45%
Manager or owner/ manager		$n = 103$	41.53%
Room supervisor		$n = 31$	12.5%
Other	Assistant/deputy/on floor manager; principal; researcher; quality mentor; inclusion coordinator; AIM support; ABA teacher; student; lecturer; Programme Lead; preschool teacher.	$n = 36$	14.52%

(3–6 years) the variance in responses reduced significantly to just 0.35, where the vast majority of the group (75.16%) determined that STEM was extremely appropriate, and a large majority of the remaining respondents determined it was appropriate (19.25%).

STEM confidence

Approximately a third of respondents (32.35%) stated that their initial qualification prepared them for STEM education. When asked to identify constituent STEM disciplines covered in their initial qualification, mathematics was the most reported (43%), followed by science (30%). In contrast, technology and engineering were reportedly covered in 17% and 10% of programmes respectively. When asked how confident they were in supporting children's STEM learning, the majority (45.03%) were confident or extremely confident (16.96%). Almost a third of respondents stated they were somewhat confident (29.82%) with the remainder (8.19%) reporting no confidence at all.

Challenges

When asked what if any challenges arose when supporting STEM learning in EC several factors emerged. While a small number stated that there were no challenges in supporting STEM (2.78%), there was some consistency in the remaining challenges identified. Lack of resources (21.72%), finding experiences/resources suitable for the age group (18.18%) and lack of knowledge about STEM (15.91%) were the most common responses. Staff perceptions (13.13%), low confidence (11.36%), time constraints (10.86%) and parent perceptions (5.3%) also appeared frequently. Further details about identified challenges are discussed below.

Policy knowledge

Participants were asked to comment on how familiar they were with policy documents that imposed STEM requirements on ECE settings. These included the STEM Implementation Plan (DES 2017b), the Department of Education Early Years Inspection Tool (DES 2018) and a government-funded online support tool (www.aistearsiolta.ie) that includes EC STEM resources (video, tipsheets, self-evaluation tools and so on). Generally, knowledge of these documents was poor, with significant numbers reporting no knowledge of any document. Table 2 provides further details.

STEM professional development (PD)

Almost all respondents (96.48%) expressed an interest in attending PD in EC STEM. A small percentage stated a preference for fully in-person training (10.56%) while the remainder preferred fully online (46.48%) or a blended approach (42.96%). A third stated they would be happy with a certificate of completion, but most favoured an accredited university qualification. Interestingly, when asked whether they would be happy to pay for such a qualification, those who favoured an accredited course stated they would, while those who preferred a certificate of completion were, for the most part, unwilling to pay. Further details about PD and its structure appear below.

Table 2. Reported familiarity with STEM policy documents.

	STEM policy and implementation plan	Education inspection tool, STEM criteria	STEM resources www.aistearsiolta.ie
Not at all familiar	78 (51.66%)	44 (29.14%)	29 (19.21%)
Somewhat familiar	48 (31.79%)	50 (33.11%)	42 (27.81%)
Familiar	17 (11.26%)	36 (23.84%)	49 (32.45%)
Extremely familiar	8 (5.3%)	21 (13.91%)	31 (20.53%)

Participant suggestions

When asked more generally about their suggestions for supporting educators with EC STEM a few key ideas emerged. These responses were particularly enlightening as they allowed respondents to expand on previous answers and suggest ways in which some of the challenges identified earlier in the questionnaire could be met. Frequent suggestions related to funding, access to information, STEM training, and the provision of STEM resources. To a lesser degree, there were suggestions pertaining to the provision of mentoring supports; the inclusion of STEM content in initial education and the national early years curriculum; the need for paid PD opportunities; and the impact of managers and colleagues on whether STEM is implemented in the setting. There were a small number of comments reflecting that STEM is present in ECE settings already; the issue identified was that educators do not recognise or label the STEM opportunities in their practice.

Discussion

Study respondents are experienced, highly qualified and have positive attitudes towards the inclusion of STEM in EC. Using Pearson's median skewness, the data was positively skewed in favour of higher qualifications (2.6), inverse to the level of qualifications typically found in the sector (Pobal 2021, 2022). Although every attempt was made to reach as wide a variety of respondents as possible, responses from level 5 and 6 qualification holders were low at 3% and 17% respectively. This is disappointing, as this group continues to make up the bulk of the early childhood workforce in RoI (Pobal 2021, 2022). The participants were highly experienced individuals, and experienced educators are more likely to value and understand the principles of STEM education than those who are less experienced (Jamil, Linder, and Stegelin 2018). This point may go some way in explaining the profile of the participants involved in this study. When reviewing findings, it was noted that many respondents are in supervisory or management roles (54%) or other support or capacity-building positions. This could imply that, as gatekeepers, those in senior positions may be the first to receive email invitations and therefore be the most likely candidate to complete questionnaires. To mitigate issues such as this, social media channels were also used to share information about the study. Although the limitations of this study do not allow us to confirm that this is the case, being able to access a broader cohort of EC educators is important for future studies and warrants further investigation.

Due to their participation in this study, it is unsurprising that 80% of participants were interested or extremely interested in STEM. Possessing an interest in STEM or having participated in STEM-related activities increases STEM self-efficacy and motivation to support STEM in EC (Chen, Huang, and Wu 2021; Stephenson et al. 2021). Only one respondent declared they had no interest at all in STEM, and this participant answered similarly to all Likert-style questions posed. The positive interest in STEM was mirrored by beliefs that STEM is an important element of EC curriculum with 90% stating it was important or extremely important. This is at odds with previous research that found a third of EC educators report that STEM was neither important nor appropriate for early childhood education (Park et al. 2017).

Early educators acknowledge the importance of STEM for children's futures and the development of strong transversal skills, but questions regarding the appropriateness of STEM in EC persist (Alghamdi 2023; O'Neill 2021; Park et al. 2017; Wan, Jiang, and Zhan 2021). Findings suggest the age range of children influenced whether STEM was deemed appropriate. This reflects previous research in RoI where preservice EC educators reported similar beliefs about the suitability of technology for babies and toddlers (O'Neill 2021). While an overall approval of EC STEM was reported, educators are less definitive in their beliefs when it comes to babies' and toddlers' exposure to STEM. There was an inconsistency in answers and a large variance rate, suggesting educators are uncertain about their reported beliefs, as they relate to younger children. This point is worth further investigation as, for example, the general public have mixed views about STEM and do not necessarily think that STEM should start early (Volmert et al. 2013). In addition, research suggests that many conflate STEM with screen time and report legitimate concerns about the health impacts of excessive use of screens on young children (Stiglic and Viner 2019; Straker et al. 2018).

Confidence level

Two-thirds of participants stated that their initial education did not prepare them to support STEM in EC. The STEM constituent disciplines reportedly included in preservice education are considerably low for science (30%), technology (17%), engineering (10%) and mathematics (30%). It was beyond the scope of this study to explore whether integrated STEM approaches were employed in preservice programmes or the extent of STEM discipline content that was covered. It is unfortunate that despite research indicating that initial ECE education programmes were not preparing EC educators to teach STEM (DES 2016), this study demonstrates that little has changed since then. The EC qualification awards criteria (DES 2019) and workforce development plan (GoI 2022) now include, albeit somewhat limited, criteria relating to STEM. Considering that education-focused inspections in Ireland include STEM criteria (DoE 2022a), and that the revised curriculum framework (French and McKenna 2023), and forthcoming literacy, numeracy and digital literacy strategy (Kennedy et al. 2023) will likely include a greater focus on STEM, it is quickly becoming a core pedagogical and knowledge requirement.

Notwithstanding the limited STEM content included in preservice training, respondents indicated high levels of STEM confidence. When analysing data, there was no clear correlation between participants reporting confidence, and reports that their initial education prepared them to support STEM. Likewise, no statistically significant correlation was found between the number of STEM discipline areas included in their preservice education and reported confidence levels. It may be the case, therefore, that participants are gaining knowledge and developing self-efficacy independently, or at least are not relying on their initial education to build their confidence and prepare them to teach EC STEM. However, confidence and competence should not be conflated. Dunphy (2018) has advised caution when interpreting self-reported findings such as this from RoI. She argues that EC educator's perceptions of what is appropriate may not align international research on STEM, and that more needs to be done to support EC educators content knowledge. Indeed, 10% of this cohort stated they had no confidence at all in supporting STEM.

Challenges

Research identifies that poor attitudes towards STEM; perceived additional workload; lack of knowledge, confidence, resources and time; and poor PD opportunities as barriers to EC STEM implementation (Jamil, Linder, and Stegelin 2018; Park et al. 2017; Stephenson et al. 2021; Uğraş and Genç 2018; Voicu et al. 2022; Wan, Jiang, and Zhan 2021; Yıldırım 2021). This correlates with the findings from this study, where lack of resources and poor knowledge of STEM were cited frequently as challenges. Respondents often referred to the need for practical supports that reflected traditions and philosophy of ECE and were easily accessible. For example, 'more practical guidance made available to help services merge theory of the STEM plan and day to day application'. The term 'practical' appeared frequently in suggestions and a significant number mentioned the provision of online supports, for example, a 'a resource centred around early years that we can access and upload to. A growable resource that can be updated with ideas and material available. Settings could share ideas and maybe collaborate with class groups'. Likewise, others mentioned social media platforms that could be used to share information and ideas. This is in line with research that websites with recorded materials are effective, particularly post-PD programmes (Buchter et al. 2017).

The opinions of colleagues and, to a lesser extent parents, were listed as obstacles to STEM. Respondents mentioned a lack of understanding and appreciation of managers or peers 'more support from the management' or 'more interest/agreement from other staff of STEM importance'. Managers are frequently agents of change within settings, playing a key role in ensuring quality, establishing a vision, and supporting the motivation and development of their team (Lee 2019). Manager beliefs about appropriateness of STEM can impact its implementation, as beliefs and attitudes of colleagues and supervisors have been shown to impact recent graduates' use of STEM in EC settings (O'Neill 2021). A number mentioned the need for STEM responsibility to be distributed among the team, stating 'knowledge shared as a whole setting, so it's not just being driven by one person' and a 'greater understanding of the importance for all involved in the setting, ensuring that all staff are on the same page'. Finally, finding suitable and affordable resources for the age group was considered a challenge for almost a fifth of respondents. In comments, the price of resources, especially good quality technology and science resources was implied. Some suggested that funding should be provided to enable settings to purchase suitable equipment, free staff up to attend training and to pay for any PD.

STEM PD opportunities

Almost all respondents (96%) expressed an interest in attending EC STEM PD, even those who claimed they had no interest in STEM. We know educators who choose to engage with PD generally possess high levels of STEM self-efficacy and their positive disposition towards EC STEM education acts as a motivator for improving practice (Bautista 2011; Chen, Huang, and Wu 2021). This has implications for the results of this study, as the participant profile suggests findings may only reflect perspectives of those who already have an interest in EC STEM. Many EC STEM policy documents presuppose that the workforce has the necessary STEM content knowledge and understanding of curriculum to implement recommendations. This is often not the case (Johnston, Kervin, and Wyeth 2022; Rogers, Brown, and Poblete 2020). Minimum qualification criteria exist in RoI, but in reality, the type and length of qualification held by individuals remains varied (Pobal 2021, 2022). To meet the needs of such a disparate cohort, a variety of PD approaches and continuing supports in various formats may be required.

Participants identified a number of approaches they felt would support their learning and adoption of STEM in their settings, including online resources, short courses with a practical focus, webinars, coaching and in-setting support. Again, the practical was emphasised 'Workshops without all the fluff, straight to the point examples and information'. Participants frequently mentioned existing regional support and training structures, indicating that these are familiar and trusted advisors. Sustained supports are more likely to have long-term impacts when they are tailored to the needs of the educator (Korthagen 2017) which existing support services are likely to be aware of, and able to meet.

Participants had clear ideas about the type of PD supports they favoured, and these varied considerably. Some preferred site visits to settings where STEM was established to get ideas and ask questions; others wanted experts to visit their setting to support the entire team; and one mentioned communities of practice to share and embed knowledge. Comments included 'Ongoing professional development with feedback' and 'Information workshops could be held at early years services to raise awareness and knowledge of STEM … '. Research into EC STEM affirms the use of these approaches. For example, coaching models, when coupled with a clear content focus and linked to practitioners' contexts, have been identified as an effective approach in EC knowledge and motivation (Rogers, Brown, and Poblete 2020; Stephenson et al. 2021). Elsewhere, communities of practice have been found to support EC educators' understanding of STEM (Boonstra et al. 2022). Furthermore, these methods can be adopted by existing support structures favoured by the setting or individual educator.

Finally, this study indicates that STEM policy knowledge is limited among participants, mirroring similar findings in RoI (DES 2020b). This is surprising, as many study participants are in leadership, management or support roles. If information of this sort is not well known among this group, it could suggest that current policy dissemination plans are ineffective. Reflecting on the level of STEM understanding in the sector, participants had varying opinions. Several respondents mentioned the unacknowledged STEM already taking place in EC settings 'I do feel it is something most educators are not aware of but are engaging in without realising'. Whereas others maintained that a level of scepticism still exists in relation to elements of STEM. 'I think staff are afraid of the concept of STEM and are not comfortable using the terms'. Some of these comments reflected Schriever, Simon, and Donnison's (2020) study that EC educators are suspicious of technology use and unhappy with the changing foci of EC towards more school-like activities.

Conclusion

This study highlights the desire of EC educators to know more about STEM, to participate in STEM PD and indicates a high level of STEM confidence among respondents. A clear regard for EC STEM was reported with 80% stating they were interested or extremely interested in STEM, and 90% stating it was an important or extremely important element of an EC curriculum. This is counter to previous studies (Park et al. 2017) suggesting a change in perceptions in recent years and bringing Ireland in line with EC STEM perceptions of other countries (Çiftçi, Topçu, and Foulk 2020; Ghazali et al. 2022; Margot and Kettler 2019; Vidal-Hall, Flewitt, and Wyse 2020). Regardless of positive reports in relation to confidence and interest, a significant number of systemic issues with STEM implementation were identified; a lack of PD and preservice education opportunities; the impact of ratios; and a lack of guidance and information at regional and national level. Further, a need for ongoing supports to deal with local challenges such as negative STEM perceptions of colleagues, managers and parents; a lack of appropriate resources; and poor understanding of STEM among colleagues, was declared. Educators in this study deem STEM inappropriate for babies and to a lesser extent, toddlers. This has implications for policy initiatives that position STEM education as beginning at birth. In practice, educators are unlikely to enact policy recommendations that are counter to their beliefs. Further, few study participants were overtly familiar with policy documents that outline STEM education obligations, despite the experience, positions and relatively high qualifications of the group.

Two-thirds of participants stated that their preservice education did not prepare them to support EC STEM, which could explain the strong interest and identified need to attend STEM PD. A variety of PD opportunities were suggested by participants and appear warranted. Findings suggest practical EC STEM tools, online resources and the inclusion of teams and managers in PD are of importance; both accredited and unaccredited PD are of interest; and mentoring and guidance from current support structures are considered appropriate. If the actions and vision of STEM policy (DES 2017a) and implementation plan (GoI 2023) are to be realised within the lifetime of the policy, at least some of these suggestions must be employed to expand and consolidate EC educator's STEM knowledge. Research in this area indicates the benefit of long-term, multidimensional programmes to deepen educational practice (Pacini-Ketchabaw, Kummen, and Hodgins 2022) and embed suitable pedagogy (Leung 2023). While this measure may be costly, investment in EC leads to improvement in quality (Bassok et al. 2021).

Overall, the study has raised several questions that require further investigation. For example, would findings be different if the qualification and experience profile of the participants were more reflective of the sector at large? Does the limited number of responses from level 5 and 6 qualification holders, who are the core workforce, represent a disinterest in STEM or did we just not manage to reach them in this study? Do educators have wholly negative views about STEM in baby and toddler rooms in EC? Does the workforce have the requisite skills and knowledge to implement the STEM policy plan (GoI 2023) as written? We recommend further study to more fully understand EC STEM perceptions and implementation in RoI. Limitations of the study, including the small cohort relative to the size of the workforce, and that the participant profile may not reflect the sector at large, are acknowledged. However, we maintain that findings add to the understanding of EC STEM, by identifying possible challenges and considerations that may influence the success of its implementation. The results are useful for those in RoI and beyond.

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ORCID

Sandra O'Neill http://orcid.org/0000-0002-4271-8163
Córa Gillic http://orcid.org/0000-0003-2976-1893
Nicola O'Reilly http://orcid.org/ 0009-0009-9031-6853

Notes on contributors

Sandra O'Neill is an Assistant Professor in Early Education at Dublin City University's Institute of Education. She is the founder and chair of the Early Childhood STEAM network. Her research focuses broadly on STEM and more specifically on early mathematics and the use of technology as a pedagogical tool.

Córa Gillic is an Assistant Professor in Early Education at Dublin City University's Institute of Education. Her research chiefly focuses on early mathematics education in early childhood settings, as well as concentrating on STEM more broadly.

Nicola O'Reilly is a lecturer in Early Education and a PhD candidate at Dublin City University's Institute of Education. Her research focus is on STEM, with her PhD research focussing on STEM learning through sociodramatic play in early childhood.

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