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STEAM Learning in Early Childhood

Editorial

Children are born with an innate sense of wonder and curiosity, and they learn about and make sense of their world through observation, exploration and experimentation. We can evoke children's interest in areas such as science, technology, engineering, arts and maths (STEAM) by offering them opportunities to engage in practical, hands-on, real-life experiences and exploratory, open-ended play.

STEAM education for young children involves teaching science, technology, engineering, arts and maths as an integrated whole. This holistic appoach not only supports children's learning in the different areas, but enables them to develop skills that extend beyond them. In early childhood education and care (ECEC) settings, when we encourage children to be creative, to experiment, to predict and to try things out, both on their own and while working and interacting with peers, we support them to develop skills in self direction, critical thinking and problem solving.

In this issue of *ChildLinks*, we consider STEAM learning in early childhood education and care settings from both an Irish and international perspective.

In the first article, Nicola O'Reilly from the Institute of Education in Dublin City University (DCU) gives an overview of the Early Childhood STEAM Network, an informal network of educators, students, academics and mentors in Ireland with a particular interest in learning more about STEAM, and outlines a study that researches how educators currently perceive STEAM education within ECEC. Dr Nuala Finucane from the Technological University of the Shannon: Midlands Midwest then considers the factors that influence the provision of science learning experiences in ECEC in Ireland, examining educators' perceptions and practices around science education. In a further article from the Irish context, Lorraine Farrell from NCCA explores how the Aistear Síolta Practice Guide can support early years educators to notice, name and support science, technology, engineering and maths learning opportunities within their early childhood curriculum.

Also in this issue, Dr. Thomas Delahunty, Assistant Professor of Education at Maynooth University, looks at the implicit gendered constructions of STEM education among early childhood educators, examining the evidence of gender stereotype endorsements among future early childhood educators and how this may contribute to the gendered subjectivity in their future pedagogic practice in the early childhood setting.

From further afield, Virpi Yliverronen from University of Turku gives an overview of technology preschool education in Finland and explores two projects that approach technology education from different viewpoints. Finally, from the United States, Dr Tracey Hunter-Doniger, Associate Professor of Creativity/Creative Arts in Education in the College of Charleston, South Carolina, considers child-centred approaches to learning, and explores creativity, play, and autonomy as essential skills that engage students in the learning process and enhance their overall enjoyment of STEAM learning.

Sinéad Lawton

Early Childhood STEAM: Networking and Recent Irish Research

Nicola O' Reilly, Lecturer and Researcher, DCU Institute of Education

The Early Childhood STEAM Network

Introduction

The Early Childhood (EC) STEAM (Science, Technology, Engineering, Arts and Mathematics) Network is an informal network of EC Educators, students, academics and mentors in Ireland, with a particular interest in learning more about STEAM in Early Childhood.

The Network, supported by Dublin City University (DCU)'s Institute of Education, provides opportunities for members to explore, share and enhance their EC STEAM practice with peers, hear from experts and gain first-hand experience in using everyday materials, tools and devices (both digital and non-digital) to support high quality STEAM practice in Early Childhood settings and beyond. Meetings take place online approximately four times per year, with in-person events such as practical demonstrations, talks or outings to relevant locations also taking place whenever possible.

In all demonstrations, discussions and activities within the Network, there is an emphasis on the everyday nature of STEAM when it is being explored by young children. In addition, play is highlighted as the optimum means through which young children's investigations of STEAM concepts can best be supported and extended. Within the Network, it is recognised that playful everyday activities that young children enjoy, such as block play, sand, water and mud play, play outdoors, food preparation, sociodramatic play and engaging with the natural world, have the potential to support young children's STEAM learning. However, the central role that an Early Childhood Educator, with a deep understanding of EC STEAM, plays in this learning process, is also emphasised.

Background

The Early Childhood STEAM Network was first established in 2020 with the aim of bringing together Early Childhood Educators and others with a particular interest in Science, Technology, Engineering and Maths (STEM) education in Early Childhood (birth to six years). At the time of the establishment of the Network, there were many indicators that Irish Early Childhood Educators lacked the necessary knowledge, skills and confidence required to support STEM learning within their settings. Modules on STEM were not mandatory within Level 5, 6 or degree level qualifications in Ireland. Additionally, recent Government reports had indicated that STEM learning achievements were deemed 'less than satisfactory' in 28% of lessons observed in Early Childhood settings (p.14), whilst STEM teaching was deemed to be 'less than satisfactory' in 28% (p.22) (DES, 2020a).

Such evidence of continuing issues with EC STEM training and practice existed in spite of the aims for Early Childhood STEM Education outlined within the

Department of Education and Skills' STEM Education Policy Statement 2017-2026 (2017a) and STEM Education Implementation Plan 2017-2019 (2017b). These documents acknowledged that 'early years practitioners require STEM subject matter knowledge, pedagogical content knowledge, appropriate skills and confidence' (DES, 2017b, p.7) and outlined aims to 'provide a variety of high-quality STEM related opportunities for early years practitioners… to support their own professional learning' (DES, 2017a, p.18).

The founders of the EC STEAM Network felt that establishing the Network could help to support the development of knowledge, skills and confidence from the ground up, rather than waiting for appropriate support and resources to come from above.

The Network

Due to the Covid pandemic, the Network's inaugural meeting, due to take place in 2020, was delayed until April, 2021, when staff from DCU's Institute of Education, Sandra O' Neill, Cora Gillic and Julie Winget Power, hosted its first online meeting. This meeting, also attended by a small number of students, Early Childhood Educators and other interested parties, confirmed the use of the acronym "STEAM" rather than "STEM" for the Network, recognising the central place of the Arts in Early Childhood settings and the important role that the Arts can play in STEM learning for young children. It was also decided that whilst each discipline would be examined in turn, a holistic approach to STEAM learning should be maintained, reflecting the transdisciplinary nature of young children's inquiries and investigations, which often incorporate disparate elements of STEAM topics.

This first meeting also allowed for important discussions to take place around what form the network would take. It was decided that establishing the EC STEAM Network as a Community of Practice (Lave & Wenger, 1991) would allow for a strengths-based and practice-led approach, which would be inclusive of all levels of experience and welcome those working as Educators within Early Childhood settings and higher education institutions (HEIs), as well as students and members of other organisations with an interest in Early Childhood Education and STEAM learning. The Network would aim to be an informal, social space in which members could identify and talk about the STEAM in their practice, share ideas and learn from each other as well as experts in the field. Whilst the ongoing pandemic necessitated meetings being held online, it was hoped that, in time, face-to-face meetings and outings would become possible, which would allow for in-person networking and practical demonstrations of STEAM activities and resources.

Since then, new roles have been established within the Network. Sandra O' Neill, one of the original founders of the Network and Assistant Professor of Early Childhood Education in DCU's Institute of Education, became the Chairperson of the Network; the author, a Lecturer and Researcher in DCU's Institute of Education, became the Co-Chair and Chloe Caulfield, a former student on the Bachelor of Early Childhood Education in DCU, who now works as an Early Childhood Educator, became the Secretary. The Network also agreed its Terms of Reference, in which its aims and intended activities were outlined to include the following:

> *The Early Childhood (EC) STEAM Network will support, connect and inform the Early Childhood community by building on research and evidence-informed practice and policy, by sharing knowledge, by identifying opportunities and by disseminating learning to an interested and wide-ranging audience.*

Since this time, membership of the Network has increased rapidly, with new members joining as interest in, and understanding of, STEAM in Early Childhood continues to grow. Members come from diverse backgrounds, including students, Early Childhood Educators, Mentors, researchers and academics, and from a wide range of sectors and settings throughout the country. This diversity in membership has allowed for fascinating presentations from both members and guests on topics such as:

- The Evolution of the Term STEAM
- The STEAM within a Mars Learning Story
- Early Childhood Perspectives on STEAM
- An Introduction to the K-LABS 4 Kids website
- Mathematics for Babies
- Counting is Complex
- Robotics Workshops with Young Children
- Sociodramatic Play & STEAM
- A talk by Hamsa Venkat - Naughton Family Chair in Early Years & Primary STEM Education at DCU
- Enhancing Maths Pedagogy in ECCE

In February 2022, as the Covid restrictions were finally lifted, we had our first ever face to face event in the Institute of Education on St. Patrick's Campus, DCU. Like for so many other people around the country, there was great excitement finally to meet each other in person. We had a wonderful, social day, which included practical workshops on:

- How to use Lego and other materials to support young children's learning of the Engineering Design Process
- Introducing and exploring the use of a range of appropriate Technology for Early Childhood Education settings

We also had a fascinating presentation on incorporating technology into an Early Childhood setting for the first time, from a member who had just been through this process.

Members of the EC STEAM Network working on an Engineering Challenge together

This was followed by another in-person meeting in July, this time a trip to ReCreate in Dublin (www.recreate.ie), who brought us on a tour of their extensive premises and resources. They also spent time telling us all about their new Programme "Wonder Maker", which is designed specifically for Early Childhood settings, and demonstrated how we could creatively reuse a wide variety of materials when engaging in STEAM play with young children. It was a really fascinating and inspiring day that took our EC STEAM imaginations in many new directions.

A display from the EC STEAM Network's visit to ReCreate

As we come to the end of another year, we are looking forward to a final online meeting in November and hoping to continue to expand our membership amongst those who have an interest in all things Early Childhood and STEAM learning. We are also intending to open membership of the Network to our Education colleagues from the Primary Sector, in the hope that we can exchange knowledge and information from multiple perspectives of Early Childhood STEAM.

> *"Playful everyday activities that young children enjoy… have the potential to support young children's STEAM learning"*

Early Childhood Educator's Perspectives of STEM Education in Early Childhood Education – A Research Survey

Introduction

As the network evolved, three of its members, Sandra O'Neill, Cora Gillic and the author, decided to conduct some research around how Early Childhood Educators currently perceive STEM Education within Early Childhood Education. A survey was developed to investigate the issues involved and disseminated amongst Early Childhood Educators throughout Ireland. The survey received responses from Early Childhood Educators in a wide variety of roles within Early Childhood Education settings throughout the country.

Preliminary findings

Although the findings have yet to be published, some preliminary findings are worth noting in terms of the work of the EC STEAM Network and the needs of EC Educators seeking to support young children's STEAM learning within Early Childhood settings.

Ninety per cent of the respondents to the survey were currently working within Early Childhood settings. Respondents were mostly very experienced Educators, with 81% of respondents having 5 or more years experience of working in Early Childhood Education. A large majority, 98%, of respondents expressed having an interest in STEM Education in Early Childhood, whilst 99% of respondents stated that they felt STEM Education was an important part of the Early Childhood curriculum. Similar numbers also felt that STEM Education was appropriate for babies, toddlers and Preschool aged children.

However, 67% of respondents felt that their Early Childhood course had not prepared them to support STEM learning in Early Childhood Education. For 89% of respondents, Engineering had not been covered in their Early Childhood course, whilst for 83% of respondents, Technology had not been covered. Meanwhile, Science had only been covered in 30% of respondents' courses and Maths had been covered in only 42% of their courses. These findings correspond to the fact that, as stated

earlier, modules on STEM have not been mandatory within Level 5, 6 or degree level qualifications in Ireland. These findings may also go some way to explaining why recent reports from the Department of Education (DES) showed that almost a third of STEM lessons observed were less than satisfactory as outlined above (DES, 2020a).

This lack of formal training in STEM subjects was also reflected in the types of challenges the respondents faced when trying to support children's STEM learning in their settings. Many felt that a lack of knowledge about STEM/STEAM was a challenge they faced, whilst others felt that finding ideas that were suitable for the age of their learners was a challenge. Other challenges mentioned were lack of confidence, parent and staff perceptions, and lack of resources and time. These types of challenges are aligned with similar findings from the DES, which reported that, for example, Early Childhood Educators were 'unsure as to how to approach digital learning in a way that was appropriate to the age of their learners' (DES, 2020b, p.26).

Respondents were mostly familiar with the STEM requirements within the DES Guide to Early Years Education Inspection (2018) and the STEM resources that had recently become available on the Aistear Síolta Practice Guide (NCCA, 2020), but many respondents were unfamiliar with the DES' STEM Education Policy Statement (2017a) and STEM Implementation Plan (2017b). These findings were similar to the outcomes of DES Inspection reports, which showed that 'there was a lack of awareness amongst practitioners of the national STEM education agenda and the associated policy statement and implementation plan'(p.19, 2020a).

Encouragingly, the overwhelming majority of respondents (97%) stated that they would be interested in attending a course in STEM for Early Childhood Educators if one was to become available. It is also worth noting that many of the challenges that these Educators felt they faced in supporting children's STEM learning and their lack of knowledge around Government STEM Policy could be overcome through the provision of such an EC STEM course. Research by Park et al. reported similar challenges faced by Early Childhood Educators when teaching STEM and recommended Professional Development to overcome them (2017).

Discussion

The DES' STEM Education Policy Statement describes a Vision for Early Childhood Educators in which they have an:

> *excellent understanding of STEM disciplines, methods and processes, provide effective and engaging STEM teaching, learning and assessment, provide collaborative environments…for STEM learning, fostering curiosity, inquiry, persistence, resilience and creativity [and] ensure the continuing development of their STEM pedagogical content knowledge and skills in and across the four disciplines.* (2017a, p.13)

The DES have also acknowledged that support to develop STEM pedagogies and facilitate STEM learning experiences in the Early Childhood sector are 'at an earlier stage of development' (2020a, p. 8) than that of other sectors and that 'further policy initiatives, supports and actions are necessary' (ibid, p.33).

The results of this survey demonstrate that Early Childhood Educators are enthusiastic about supports such as Professional Development in STEM Education, which could, alongside the kinds of activities being engaged in by the EC STEAM Network and the resources on the Aistear Síolta Practice Guide, work together to start fulfilling the Vision for Early Childhood Educators to which the DES aspires.

If you would like to join the EC STEAM Network, please email:

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Factors Influencing the Provision of Science Learning Experiences in Early Childhood Education in Ireland: A Case Study of Educators' Perceptions and Practices

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In recent years, empirical research has shown that young children learn and think similarly to scientists as they observe, hypothesise, experiment, and evaluate during everyday experiences (Gopnik, 2012). Research also informs us that incorporating science learning experiences into an early childhood education (ECE) programme benefits other areas of learning, such as language, literacy, and mathematics (Clements & Sarama, 2016; Gerde et al., 2013), social and emotional development (Cremin et al., 2015) and scientific literacy (Booth et al., 2022). The early childhood educator plays a critical role in promoting holistic learning. This article aims to explore some of the factors that influence educators' provision of science learning experiences. A doctoral research study that investigated early childhood educators' perceptions and practices in science informs this article. While several factors influence science education, this article will focus on dominant views surrounding how children learn and pedagogical approaches to science learning in ECE.

How Children Learn

Constructivism is currently regarded as the dominant way of thinking about science education (Agarkar & Brock, 2016). Constructivist learning theory is concerned with how children make meaning of events, and learning is viewed as a process of active discovery (Hoy et al., 2013). In recent decades, two constructivist theorists have influenced ECE practices, namely Piaget (1896–1980) and Vygotsky (1896–1934).

Piaget's theory is based on the premise that learning is considered an individual act where children construct knowledge through physically manipulating their environment as they explore and discover their world. Activities deemed appropriate in this sense are those that drive development, and the adult who ascribes to such a view acts as a facilitator rather than an educator (Hatch, 2020). They believe that merely providing materials for sensory manipulation and exploration will result in children learning about science concepts.

The Sociocultural approach of Vygotsky and his followers emphasises the critical importance of the social and cultural context of learning (Vygotsky, 1978; Wertsch, 1985). Although also a developmental theorist, Vygotsky believed that learning is fundamentally a social activity in which the child learns from interacting with a more knowledgeable other. According to Vygotsky, such interactions provide a platform for the child to achieve their learning potential. He explains the process through his theory of the zone of proximal development (ZPD). Educators who ascribe to Vygotskian principles will provide science learning experiences by scaffolding investigation skills and scientific concepts that are just beyond the child's level of independent functioning. As a result, the child's requirement for support reduces as their learning and development progress. The role of the adult in this instance is that of an educator, who scaffolds content-rich activities to support the child's learning (Hatch, 2020).

Pedagogical Approaches to Science in ECE

According to Lazonder and Harmsen (2016), inquiry-based learning (IBL) involves students investigating phenomena by conducting experiments, observing or collecting information. These investigations are guided by questions posed by either the child or the educator. Several research studies show that when educators receive training in science-based IBL, they can enhance children's science learning. For example, Dominguez et al. (2013) used Bybee et al.'s (2006) 5E model (Engage,

Explore, Explain, Elaborate, Evaluate) to investigate 'wiggly worms'; Hoisington et al. (2014) describe the use of a variant of the 5E model, the Engage-Explore-Reflect cycle, to investigate water.

In the context of science education, Harlen and Qualter (2014) maintain that '[t]eachers' questioning is one of the most important factors in determining children's opportunities for developing their understanding and inquiry skills' (p. 148). However, not all question types promote investigations and problem-solving. Questions can be either open-ended, allowing for several answers, or closed, which prompt a single correct response. Although educators recognise the crucial role of questioning in education, research suggests that they rarely pay attention to the form or quality of questions asked (Crowe & Stanford, 2010). Indeed, studies show that closed questions dominate (Günay Bilalo lu et al., 2017; Siraj-Blatchford & Manni, 2008). Young children are innately curious, and when faced with continuous closed questions, their interest in engaging in any form of inquiry learning is likely to be quite limited (Harlan & Rivkin, 2014).

Many aspects of inquiry learning exist in children's play. For example, recent work by Fleer (2019) explores the use of children's story books as a stimulus for children's inquiries through sociodramatic play. While this and other studies show that IBL provides a catalyst to challenge children to move beyond the sensory exploration of materials and to explore phenomena using scientific skills, young children need support during their investigations, and a knowledgeable educator provides that support.

A knowledgeable educator understands scientific concepts and the pedagogical skills associated with IBL (Harlen, 2013). In other words, they have science-based pedagogical content knowledge (PCK) (Shulman, 1986, 1987). Shulman recognised that educators have two types of knowledge, pedagogical knowledge and content knowledge, the former being the 'how' of teaching and the latter the 'what' of teaching. However, several studies have found that many early childhood educators lack confidence in effectively supporting young children's science learning due to a lack of scientific knowledge (Lippard et al., 2018; Roehrig et al., 2011).

Furthermore, educators' lack of science-based PCK may explain why educators' provision of science learning opportunities is frequently limited to sensory exploration. In their study, Inan and Inan (2015) found that science activities tend to focus on children 'doing' through a 'hands-on' approach and rarely involve a further scientific investigation. A similar point is made by Worth (2010), who notes that while many classrooms have a science table filled with interesting objects and observation tools such as magnifying glasses and scales, sensory interactions are often the extent of the science inquiry as children's observations and questions frequently remain unanswered.

Methodology

This qualitative multi-site case study aimed to critically examine the various factors influencing educators' provision of science learning experiences from an Irish perspective. Participants were selected using purposive sampling. Educators working in a room leader capacity with children aged 3-5 years were chosen as they are responsible for curriculum planning, pedagogical practices, and resource provision. The participants' qualification levels ranged from Level 6 to Level 9, and their experience in ECE practice ranged from 8 – 20+ years. Over the course of eight weeks, data were gathered using two methods, video observation, and interview. Video observations of the practice of science education included the science-related materials freely available in the environment, unplanned science-related incidences, and planned educator-led activities. Semi-structured interviews were used to explore how the educators perceive science in ECE. A total of 23 videos and eight interviews were transcribed and analysed using inductive thematic analysis. However, for purpose of this article only the data from the 14 planned educator-led activities are used. To preserve participants' anonymity, they are identified as T1 – T8. Ethical approval was granted by the University of Sheffield Ethics Review Board. All data were managed in accordance with the *Data Protection Act* (Ireland, 2018).

Findings

Several themes emerged from the data analysis: educators' beliefs about how children learn, educators' science-based PCK and training, and associated pedagogical practices, including the role of children during activities.

Educators' beliefs about how children learn

Educators' beliefs about how children learn will impact the science learning opportunities they provide in the classroom and how they view their role (Hatch, 2020). Analysis in this study revealed that all participants articulate interpretations of Piaget's view that children learn through active participation, which primarily involves physical hands-on and multisensory experiences. As T2 explains, '*Children learn through doing. It's certainly not listening…that does not work at all in this environment. Let them explore it and manipulate it and see results from their ideas*'. Considering this interpretation, it is not surprising that the participants describe their role in terms of providing resources and facilitation. As T8 states, '*Generally, my role would be to provide the equipment…and then I let them work away to explore for themselves. So, I'd be a kind of a facilitator, I suppose*'. Learning as a sociocultural process with peers and adults was given little emphasis other than forming groups. However, within the group, each child acted as a solitary explorer of the materials.

Educators' Science-Based PCK and Training

Educators' lack of science-based PCK and training is often cited as one of the primary obstacles to providing science learning opportunities (Gropen et al., 2017; Park et al., 2016; Pendergast et al., 2017). Analysis of the interview data shows that only participant T8 received formal science training as part of her BA in Montessori education. The only other reference to training was made by two participants who attended a three-hour course on science in ECE facilitated by the local Childcare Committee. While attendees covered *a 'little bit of the science'* (T2), pedagogy was not mentioned. Furthermore, while participants were positive about the influence of *Aistear: The Early Childhood Curriculum Framework* on their general practice, only one participant mentioned it in relation to science, noting the lack of information about practical ways to implement science. '*I find Aistear is very good for giving ideas but not practical solutions. So, it doesn't give you a practical way to look at science. It doesn't give you ideas of what you should be doing. You know you have to come up with all of that yourself.' (T8)*

As outlined above, according to Shulman (1986, 1987), educators need to know the 'what' and the 'how' of teaching, Pedagogical Content Knowledge (PCK). However, concerns have been raised in the literature that early childhood educators lack science content knowledge, in other words, the 'what' of science teaching (Fleer, 2009a; Nilsson & Elm, 2017). Findings from the present study suggest that most participants were aware of their lack of scientific knowledge. Some also identified this as a reason for not explaining the science that underpinned the activities. As T5's remarks demonstrate, '*I don't explain the science behind it. I suppose I'm not great at that because I don't know myself.*' When asked about the 'how' of science teaching, only two participants recognised their need for more training. Despite all participants recognising their lack of science content knowledge surrounding the 'what' and, for some, the 'how' of science teaching, all participants regularly include science activities as part of their curriculum.

Pedagogical practices

Questioning

According to Harlan and Rivkin (2014), educators' questions play a fundamental role in scientific inquiry learning and directly impact the quality of that learning. Analysis of the observation data revealed that questioning was the most common pedagogical strategy used during science activities. All educators asked questions, and of the 96 questions, only one was open-ended, representing 1.04%. This finding is lower than both the 5.5% reported by Siraj-Blatchford and Manni (2008) and the 10% reported by Günay Bilaloğlu et al. (2017). The participants in my study used closed-ended questions as a form of assessment. They asked questions either to establish the children's existing knowledge or to assess whether they could recall the steps of the activity. In the first instance, where questions were used to elicit factual responses, some of these questions were quite complex and abstract, which often led to abstract explanations by the educator.

The role of children

Analysis of the data revealed that the role played by children during the activities varied. Three categories emerged. Category one included four activities that involved making substances such as gloop or playdough. During these activities, the children had to follow the educator's instructions when taking their turn pouring or mixing. When the gloop/playdough was made, their involvement centred on a hands-on exploration of the materials. Category two included seven activities, a representative example involved 'making a tornado'. This activity involved using a commercially available 'tornado stop' attached to two plastic bottles, one of which contained water. Similar to the first category, the children's participation involved following the educator's step-by-step instructions to achieve the desired result and turn-taking. However, on completion, the children then simply observed the phenomena (tornado). The third category included three activities where the children's role was that of passive observer. A typical example involved the educator adding a Mentos mint to a bottle of Coca-Cola. Science concepts were not mentioned or explored during any of the activities.

Play

Considering the significant emphasis on play in early childhood education, it was not unexpected that all participants expressed the view that children learn about

science through the medium of play, primarily sensory play. As T8 describes, '*They learn during the sensory experiments, this is fun… it's playing. It's kind of not a science experiment as such.*' However, despite such beliefs, of the 14 planned science activities observed for this study, only four involved (sensory) play.

Discussion

When confronted with 'doing science', the findings indicate that Piagetian beliefs about how children learn inform participants' decisions. They provide activities that only involve exploration and discovery, as they believe this is how children learn. However, this exploration and discovery may simply involve the children engaging in some hands-on activities, such as pouring liquid or playing with playdough. There was little evidence to suggest their beliefs reflect a Vygotskian sociocultural approach to science learning. The educators assumed direct control of the process throughout the planned activities, and didactic interactions dominated the pedagogical practices. This tension between participants' beliefs and practices draws attention to educators' challenges when presenting children with scientific concepts and providing explanations that children will understand.

According to Spektor-Levy et al. (2013), most planned activities facilitate sensory exploration, which assists scientific thinking as children engage, explore, manipulate and interact with their environment. However, Bybee and colleagues (2006) propose that engagement and exploration are only the beginning of scientific inquiry. Therefore, the educator's challenge is to develop such explorations by guiding the children's interests and everyday experiences into further science learning. However, analysis of the data indicates that this development did not happen. There was little focus on scientific concepts or the skills of inquiry.

The learning opportunities educators provide for children are also directly linked to their knowledge and understanding of science (Fleer, 2009b; Pendergast et al., 2017). The educators in this study had little awareness of appropriate science-based PCK. Appropriate in this sense means that the educators did not mediate the children's science learning through educator-child interactions within inquiry-based activities. These activities should be framed around scientific concepts and linked to children's everyday conceptual understanding (Cremin et al., 2015; Gelman et al., 2010).

Educators' pedagogical decisions as they support children's learning reflect their own beliefs about how children learn, their values, and the knowledge and skills attained during training and through experience (Alexander, 2008). Due to a lack of training, most educators have had limited opportunities to gain science content and inquiry-based pedagogical knowledge. This lack of training concurs with several studies, which conclude that many early childhood educator preservice training programmes do not adequately prepare students to support children's science learning (for example, see McGuigan & Russell, 2017; Park et al., 2016). Importantly, *Aistear* does mention using experiments to explore concepts such as gravity and floating and sinking. However, this approach to curriculum means that effective implementation of *Aistear* is highly dependent on educators' theoretical, content and professional knowledge.

Conclusion and Recommendations

A web of interrelated factors influence educators' provision of science learning experiences; central to this are their beliefs about how children learn, educators' PCK and training. The educators in this study demonstrate a Piagetian view that children construct their science knowledge by physically manipulating their environment. Limited consideration is given to what children are thinking about during these explorations. As a result, children's engagement with and exploration of materials did not extend into any further inquiry-based learning opportunities. Educators' beliefs also explain why the participants view their role in science education as a guide and facilitator who provides resources for children to engage in discovery and exploration (Hatch, 2020). A critical influencing factor was that these educators received little or no training in science and consequently lacked an understanding of science-based PCK.

Since the research that informed this article was completed, some higher-level training institutions have introduced STEM modules as part of their undergraduate offering, and this is a welcome beginning. However, appropriate continuing professional development training for practising educators remains scarce. Therefore, a key recommendation is that funding is made available to provide CPD training courses on learning theories and science-based PCK to support practising educators. It is also important to note the welcome review of *Aistear* that is currently underway.

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Improving STEM Education... But for Whom?

The Implicit Gendered Constructions of STEM Education Among Early Childhood Educators

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Some Context on STEM Education

Science, technology, engineering and mathematics (STEM) is widely understood as a core driver of socioeconomic advancement in the Western world and this centres education in this area as pivotal to a nation's prosperity. Irish governmental exigencies for the national improvement of STEM education are well established and captured in the national STEM Education Policy Statement 2017-2026 (DES, 2017). A notable focus that appears in the policy, and subsequent narratives surrounding STEM education development in Ireland, is the role of early years education in nurturing young people's dispositions and abilities in STEM disciplines. This policy narrative positions the need for a 'national focus on STEM education in our early years settings and schools to ensure we have an engaged society and highly-skilled workforce in place' (DES, 2017, p.5). Suspending scepticism towards the obvious neoliberal forces in this extract, early childhood is indeed a sensitive period of development where the basis for future knowledge, skills and attitudes are formed.

The signposting of this period, within national policy, aligns with international literature highlighting the developmental period, which encompasses the early childhood years, as an optimal time to allow pupils to experience STEM education through play-based learning opportunities (Simoncini & Lasen, 2018). Authors, such as Tippett and Milford (2017), argue that the innate curiosities and drive to understand their experiences in the world align with the core nature of STEM education and the 'hands-on' learning it entails. These innate motivators in pupils coincide with a highly sensitive period of development where cognitive and academic achievements often form lasting effects well into later adolescence and adulthood (e.g., Kuang & Flouri, 2021). If we extrapolate the developmental sensitivity apparent in the early childhood period to the issue of gender representation in STEM – a pervasive issue, well-established in the broader literature – some promising opportunities, ostensibly, present themselves. The problem of female underrepresentation in STEM

education has become a widespread discourse across all strata of education, industry, and government. This issue is well captured in data from the Irish context. For example, in Ireland, only 13% of engineering graduates are women (Engineers Ireland, 2019), 21% of ICT specialists are women (EIGE, 2019) and 25% of those working in Ireland's STEM industries are women (Daly et al., 2018). This is similar to other international contexts such as in the UK and US where, respectively, 22% (WISE, 2018) and 24% (Noonan, 2017) of STEM workforces are comprised of women.

Speaking of Gender

Of course, these trends across STEM areas have motivated research agendas aimed at seeking causal explanations for this striking inequity, as well as investigative programmes seeking optimal interventions for recruiting and retaining females in STEM across different levels of education. For example, Sheryl Sorby in the United States has devoted much of her research career to understanding the role that spatial cognition (the ability to interpret and manipulate visual information in the mind) plays in narrowing the gender gap at University levels. Her research (e.g., Sorby, 2009; Sorby et al., 2013; Sorby, 1999) has contributed significantly to understanding the role of cognitive abilities in enhancing retention of females in STEM, as well as developing effective interventions to enhance these abilities. The importance of these cognitive abilities in STEM achievement is well supported and work from Wai et al. (2009) establish spatial competencies as stronger predictors of success in these fields, over both math and verbal ability. The phenomenon that females have been consistently found to underperform in measures of spatial cognition[1], compared to males (Casey, 2013; Levine et al., 2016), lends credence to the notion that enhancing these talents would address the gender representation issue. The relevancy of this phenomenon for early childhood education is furthered by similar findings with young children (Newcombe & Frick, 2010; Newhouse et al., 2007) and even infants (Constantinescu et al., 2018). The enhancement of spatial skills among pre-school populations is also a noteworthy avenue of investigation, with research from authors such as Joh (2016) demonstrating some initial success in this area. While addressing these performance discrepancies, for this particular ability, undoubtedly contributes to addressing the overall issue, it is but one element of the complexity of the gender inequity issue in STEM education.

Gender Stereotypes and the Construction of STEM identities

Cutting to the chase, so to speak, it would be a mistake to infer, from the cognitive line of research, an encompassing etiology for the issue of female underrepresentation in STEM education. To do so requires the construction of the female subject as innately inferior with respect to certain cognitive abilities, that prevents their success in STEM fields. Furthermore, recent research has cast firm doubts on these developmental/biological limitations impeding female success in STEM fields (Else-Quest et al., 2010; Li et al., 2018; Reilly et al., 2019), supporting the position that females can perform equally as well as males in these fields of study and work. This evidence suggests that the root of the gender difference also lies with broader psychosocial variables, in addition to any cognitive factors. One such psychosocial perspective, which concerns lay understandings of male superiority in these fields, are the widely held set of gender stereotypic beliefs in broader society, attributing STEM fields as masculinely-aligned (Sanchis-Segura et al., 2018).

Stereotypes in relation to gender develop from as young as two years of age (Ruble et al., 2006). In particular, from preschool onwards, gender is utilised to classify and compare individual selves relative to others in a social group in the process of constructing a gender self-identity (Renno & Shutts, 2015). Gender identity relates to the manner in which an individual perceives themselves to be masculine or feminine, given the social reality of what it means to be either in a particular context/ society/culture (Vantieghem et al., 2014). Considering gender stereotypes, which conceptualise STEM pursuits as masculine, signals a potential for dissonance between STEM and feminine gender identities.

In order to achieve success in STEM education, the construction of a positive STEM identity is critical (Seyranian et al., 2018). Where uncertainty surrounding a particular social identity occurs – such as gender or STEM belonging, in this case – individuals are motivated to seek out identification with a social grouping to alleviate the unwanted psychological discomfort (Hogg, 2007). Moreover, the individual will seek a social grouping with clearly defined borders and homogeneity of members (Hogg et al., 2007). This theory would therefore support the idea that many women may perceive STEM as dissonant with their gendered identity, which appears as the highest entitative choice when an individual is in

1 This trend should be cautiously interpreted as recent literature has problematised some of the findings ascribing male superiority in spatial ability being subject to numerous moderator effects, including both measurement and testing conditions. See for example Lauer, J. E., Yhang, E., & Lourenco, S. F. (2019). The Development of Gender Differences in Spatial Reasoning: A Meta-Analytic Review. *Psychol Bull*, *145*(6), 537-565. https://doi.org/10.1037/bul0000191

the situated context of STEM education. If stereotypic beliefs are therefore endorsed on the part of a female student, the potential for a maladaptive STEM identity (contingent on deferring to a heightened construction of feminine identity) is increased. This is summed up best in a quote from an anonymous female in a study carried out by Burton (1990, p.20): "it's fashionable not to like math's – when you're at secondary school they think you're weird if you like math's . . . . . . especially if you're a girl". Extrapolating these ideas back to the early childhood context, where the foundations of children's gender identities are laid, centres the role of the early childhood teacher.

Gender Stereotypes and Early Childhood Education

Processes of socialisation and vicarious experiences influence children's identity formation throughout their educational journey (Brey & Pauker, 2019; Lagaert et al., 2017), with teachers being significant sources for these experiences in the classroom. In the Irish context, the role of stereotypes in teachers and parents' evaluations of children's capabilities in mathematics has recently come to the fore. Mccoy et al. (2022) have provided compelling evidence of stereotyping among teachers, with teachers being 1.5 times more likely to rate males' ability higher than females' in mathematics subjects (p.358). Furthermore, the authors highlight that female teachers are less likely to rate children as above average compared to their male peers, delineating this as reflecting an 'internalised devaluation of themselves' (Mccoy et al., 2022, p. 358). This worrying finding indicates a significant potential issue for school going children given the salience of pupil-teacher interactions in influencing the development of the child (Kollmayer et al., 2018), especially given the predominantly female demographic of the early childhood teaching profession in Ireland (Pobal, 2019).

Within the international literature in early years education, there is emerging evidence of the effects of gender stereotype beliefs, held by teachers, on the beliefs and behaviours of preschool aged children. In a study investigating the mediating role of preschool teachers' gender stereotype beliefs, Wolter et al. (2015) found that the more traditional a teacher's stereotype view was, the poorer their male students' motivation was for reading, while girls' motivation was unrelated, reflecting the stereotype of female advantages in this area. Furthermore, evidence of the implicit transmission of teachers' gender stereotype endorsements through their pedagogical practices were found by Callahan and Nicholas (2019), where preschool teachers engaged in gendered teacher-child interactions, encouraging only female children to play a "hairdresser" game. It is therefore apparent that trends of stereotyped practices are occurring in the early years classroom, which could threaten the development of positive STEM identities among younger children.

Early Years Teachers' STEM Identities

The instances of gendered practices reported within the broader literature and the recent evidence of primary school teachers' potent gender stereotype endorsements, indicates a potential misalignment of STEM and gender identity among practitioners. This possibility is alluded to by Mccoy et al. (2022, p. 358) identifying teachers' lack of ability to acknowledge their students' excellence as reflective of their own stereotypical insecurity as females making judgements in the subject of mathematics. Similar lack of confidence is noted in the early years teaching profession when it comes to delivering lessons related to STEM education. Despite a generally positive disposition to the integration of STEM education in early years education (Y ld r m, 2020), there are notable concerns among practitioners related to their feelings of preparedness to teach these areas (Park et al., 2017). These findings, taken as a whole, highlight the potential for teachers' STEM self-concept to be somewhat impacted by their gender stereotypic endorsements of STEM disciplines as unsuited to females. This is a particular cause for concern in the context of early years teacher education especially as Cohrssen and Tayler (2016) exert that much research with this population tends to uncover negative attitudes

towards STEM disciplines such as mathematics. If malformed STEM identities, presaged by factors such as low STEM/mathematics self-concept and gender stereotype endorsements, resist reflection and revision in the period of teacher education, then it is entirely likely that the young teacher will carry these characteristics into their professional practice with children.

As limited research exists, and to the best of knowledge none in the Irish context, with early childhood student teachers, this formed the goal of recent work in the RAISE (Research, Application and Inclusion in STEM Education; www.raise-stem.ie) group. Within this recent study, a questionnaire was delivered to a sample of 3rd year undergraduate early childhood student teachers (ECSTs) containing measures of gender stereotype beliefs, mathematics self-concept and attitudes towards STEM disciplines. The purpose was to investigate, using a linear modelling approach, the relationship of gender stereotype endorsement and mathematics self-concept (chosen as the one STEM subject all participants had experience of) to STEM attitudes. The findings of our study revealed that attitudes endorsing humanities disciplines as more feminine than STEM, predicted more positive STEM attitudes. Interestingly, when ECSTs self-concept in mathematics was entered into the model, it completely mediated this relationship. This builds on McCoy at al. (2022) who have suggested that female teachers may possess a stereotypical insecurity in STEM, which inhibits their ability to see student achievement in these fields, by highlighting the role self-concept plays in predicting ECSTs' attitudes to STEM. The reader is directed to the pre-print of Delahunty et al. (2020) for further details on this work.

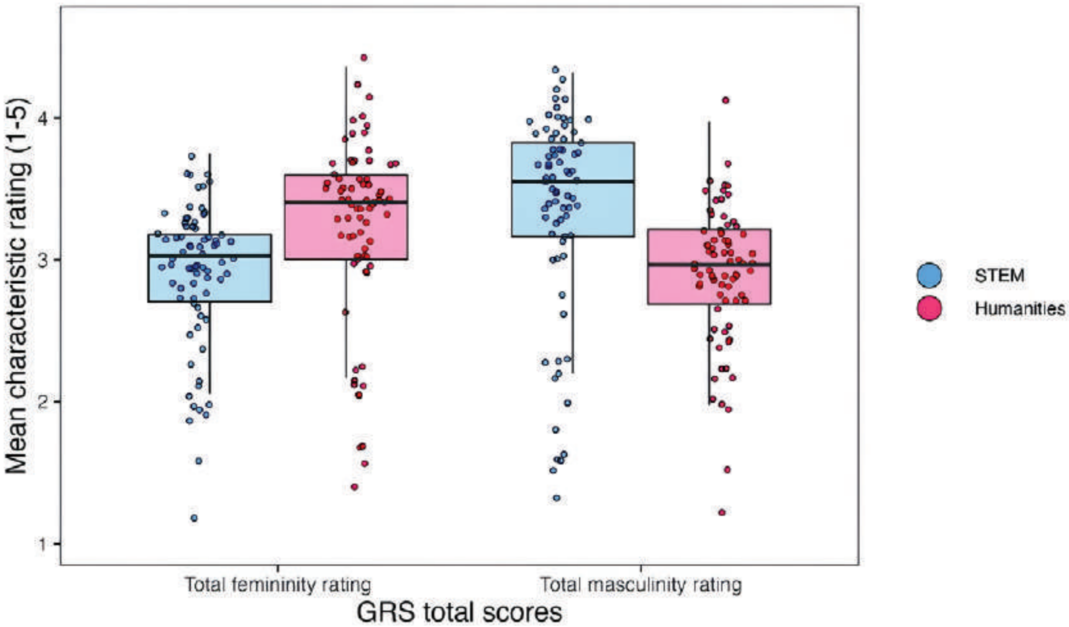

Figure 1: The stereotype endorsements of early childhood student teachers in Delahunty et al. (2020)

Concluding Thoughts

Based on the results from our recent work in the Irish context, two main conclusions are supported. Firstly, as shown in figure 1, ECSTs hold notable gender stereotype beliefs towards the humanities and STEM, affirming gendered identities of feminine and masculine respectively. This is concerning given the potency and resilience of such beliefs, as well as their potential intrusion upon ECSTs future pedagogic practice in the early years classroom setting. The second major conclusion relates to the role that ECSTs self-concept in STEM areas holds in determining one's attitude towards the STEM subjects. Along with the evidence of gender stereotype endorsements among these future early childhood educators, there is indication that the insecurity ECSTs have in their STEM ability may be contributing to the gendered subjectivity ascribed to STEM among the sample. This signalizes an insidious cycle of teachers' gender stereotype endorsements, linked to their own subjective self-identification/ confidence with STEM disciplines as determinants of their attitudes and interest in the field. Moreover, the fact that these beliefs have the tendency to permeate one's professional practice forefronts the reality that any policy aimed at integrating cohesive visons of STEM education in early childhood curricula may be somewhat tautological if these beliefs are not challenged and addressed in the course of the individual's teacher education.

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Creativity, Autonomy, and Play:

Key Factors to Child-Centred Approaches and STEAM

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Introduction

In the United States, traditional public schools spend an exorbitant amount of time preparing students for high-stakes testing (Nichols & Berliner, 2007; Wall, 2000). Increased regulations have caused a stifling halt in creativity, enjoyment, and autonomy in the classroom (Nichols, & Berliner, 2007). As a result, students react to assignments with an automatic, almost Pavlovian, response of 'What do you [the teacher] want?' Students have little to no commitment to the assignments, because they see little to no value in learning the content beyond the project's grade (Wall, 2000). Students want to know what the teacher expects, and they want to deliver it exactly how it is anticipated. Independent thought is not discouraged, but it is not encouraged either. Even if children are interested in a topic, it is quite rare for them to delve deeply into content beyond the established testing measure.

Let us be clear, this didactic way of teaching it is not to be blamed on the teachers. In the schools today, teachers are required to comply with mandated directives such as scripted curriculum. This curriculum is often described as "teacher proof" as the entire year is presented for the teacher to read to the class. Scripted curriculums are often paired with pacing guides, which are provided by each district as benchmarks for learning. These concepts seem harmless enough in theory and could work if teachers were instructing identical robots. However, scripted curriculums and pacing guides are problematic because they do not take into account students' level of understanding at the beginning of the school year, and do not allow for more time if the children do not understand the concepts and need more time for mastery. They clearly do not consider the engagement or the interests of the students.

An Alternative Method of Teaching

What if educators considered a child's curiosities? How would that change the curriculum and the child's interest in learning? What if a teacher was able to allow for in-depth exploration and examination? What if children were empowered with a passion for learning, instead of learning rote memorisation for high-stakes testing? What if we used pedagogical practices that produced more innovators? Could we pursue a pedagogical model that cultivates innovative thoughts instead of the "teacher-proof" models that demand class learn exactly the same thing at the same time? I have heard more than one principal say with pride, 'If I walk out of one kindergarten class I can walk into another and know exactly what page they are on in their book.' Now that kind of rigid predictability may be desirable for assembly line workers, but it does not help to stimulate the minds of young people. It is the opposite of what should happen in our schools. Rigid does not equal rigor. More effective pedagogical methods have been designed that embrace students' interests while still adhering to the curriculum. It is time to embrace child-centered pedagogies like the Reggio Approach, and Forest Schools.

Child-Centered Pedagogies

A paradigm shift is taking place in instructional leadership at the early childhood and elementary level (ages 3-10), especially since the COVID-19 Pandemic. Juxtaposed to the scripted curriculum, child-centered approaches, where children's interests lead the curriculum as the teacher facilitates, are being discussed and written about in journals such as the *Early Childhood Journal, Early Years* and *Childlinks*. A child-centered approach to learning is a method of teaching in which children actively participate in their education and make choices about the direction their learning will take (Moyer, 2001). This approach to early childhood learning dates back to German education in the early 1800s and is associated with Friedrich Froebel, who conceived of kindergarten and believed that the child's whole development was important in education. Froebel established schools that included play, art, and physical and mental wellness as well as academics (Henson, 2003). Studies have shown that children develop motivation to learn when they are engaged in topics they find interesting (Katz & Chard, 2000). Once children are engaged, they are more likely to apply their critical thinking and problem solving skills to perform integrated investigations that produce detailed projects. The divergent nature of this pedagogical style requires student progress evaluations to include time spent on chosen projects, photographs of children working, and observational notes. The notes record comments the children make, how they work collaboratively, the daily questions that each child posed, and how the child approached the query. These documents are presented in a portfolio to the parents as a robust assessment of the child's individual learning, progress and interests. During the developmental stages of early childhood and elementary education, this comprehensive educational portfolio provides more information than a single letter grade. Three established examples of child-centered learning are the Reggio Approach, the Forest Kindergarten model and Teaching Artistic Behaviors (TAB).

The Reggio Approach

The Reggio Approach originated in Reggio Emilia, Italy, after World War II. The people of Reggio decided that the post-war future of their country depended on their children and chose to focus efforts on early childhood education that embraced child empowerment (Wurm, 2005). The Reggio Approach views the child as a researcher and focuses learning on the children and their interests (Wurm, 2005). Curriculum is completed through projects, art making, exploration, and socialised play. Loris Malaguzzi (1993), who led the development of the Reggio Approach, described children as the 'authors of their own learning' (p.55) and encouraged children to investigate items and concepts for hours and sometimes days. The length of time spent investigating depends on the children's desire to persist and explore. Malaguzzi contended that children have one hundred languages or ways of viewing the world and are beings with the capacity and aspiration to construct their own knowledge (1993). In the Reggio Approach, children are free to learn, discuss with their classmates, and reflect in their own ways. The arts are considered one of the hundred languages and are a major part of the Reggio Approach (Wurm, 2005; Malaguzzi, 1993). The

Reggio Approach uses drawing, constructing, modeling, painting, and building to deepen students' knowledge and help them form concrete understandings where they are emboldened to learn academically and to extend learning to life beyond school (Hunter-Doniger et al., 2018). Many aspects of the Reggio Approach can be found in the autonomy found in Forest Kindergartens.

Reggio – Child exploring colour

Forest Kindergartens

Forest Kindergartens, which originated in Europe, permit students to lead instruction based on curiosity as they spend nearly the entire school day outside (Powers-Costello, 2015). In Germany, Forest Kindergartens, also known as waldkitas, encourage preschool-aged children to learn by playing in nature, and the curriculum is presented based on the children's interests (Schäffer & Kistemann, 2012). In Forest Kindergartens, nature is the spark that ignites learning as children become more in touch with ecology and the environment. In a Forest Kindergarten, children's natural curiosity is encouraged. Children are free to splash, climb, and get dirty as part of the learning process. Children may wonder off, only to return with an interesting leaf or rock to share with the class, which creates a new dialogue and becomes the subject for discussion. This child-centered model is directly linked to Froebel's creation of kindergarten and his emphasis on children learning in nature (Sobel, 2014). Children are able to participate in their learning, formulate questions, and convey explanations that are based upon their worldview and experiences, much like when they create art.

Forest Schools encourage learning through play in nature

Teaching Artistic Behaviours

TAB (teaching artistic behaviours) is a relatively new method of teaching visual arts. It is a child-centered approach where children are permitted to choose their learning paths and their art explorations. TAB enables students to experience working as artists through genuine artistic learning opportunities. Within this pedagogical structure, students are given authentic options that embody their own ideas and interests while making art, and teachers meet students' diverse needs through multiple modes of learning. Therefore, the students are in the driver's seat as they decide the path and process they will take, and they communicate their answers as they find them. Teachers work as facilitators and provide opportunities for learning, teach necessary skills, and assist in guiding children to solutions. TAB puts the emphasis on educational content and experiences rather than standardised assessment (Parks, 1992). This method of teaching can be achieved if teachers have the option to give students the freedom to work at their own pace and make learning personal through individual inquiry. When children have more control in the learning process, they can take ownership of their education.

TAB classrooms allow children to learn through individual inquiry

What are the Benefits of Child-Centered Pedagogies?

Children and their educational needs have changed since the beginning of public education. Child-centered approaches to learning differ greatly from traditional models of teaching and provide several benefits to the educational process such as increased creativity, play, and autonomy. On the surface, creativity, play, and autonomy may seem less important than content standards, but they are essential skills that engage students in the learning process and enhance their overall enjoyment of learning.

Creativity

Since people express creativity in a myriad of ways, creativity can be difficult to define. It is often linked with the arts, sciences, and literature, and portrayed as a special and unique trait that only a select few possess. Synonyms for creativity include innovation, cleverness, resourcefulness, productivity, inspiration, and ingeniousness. Creativity is associated with new ideas and unique solutions. Howard Gardner studied creativity extensively before conceiving his theory of Multiple Intelligences, which suggested the limitations of traditional notions of intelligence and presents nine different types of intelligence (2011). Studies show that child-centered approaches encourage and resonate with creative mindsets. For instance, one study states that children's creativity develops during the early years of education and starts the foundation for human capital (Walberg, 1988). Another study argues that there is a correlation between creativity and long-term skills such as entrepreneurial capabilities, but traditional educational pedagogies discourage creativity (Zhao, 2012). To promote and encourage creativity in a learning environment, children need to have time to explore and investigate though play.

Autonomy

In contrast to a traditional didactic approach to learning where the teacher lectures the entire class and the students are passive participants in the learning process, child-centered approaches give students autonomy. Autonomy in child-centered pedagogies benefits both the students and the teachers. The autonomy in these environments empowers students to construct their understanding and knowledge. Correspondingly, when teachers are provided autonomy in their classroom, they feel empowered and trusted as a professional. As child-centered approaches do not mandate a ridged pacing guide or scripted curriculum, teachers can instruct the best way they see fit for their students. The teachers are also less stressed because they can focus on individual children's needs and not feel pressure to teach based on an unrealistic timetable. If some children are compelled to learn more physically, vocally, or artistically, that is ok. Imagine how having that amount of freedom could influence the learning process.

Play

In a child-centered learning environment, learning takes place using a model where children are not explicitly taught but rather shown, usually through individual discovery or discoveries shared with a group of peers (Alcock & Ritchie, 2018). The environment changes how students use their imagination, and play stems from a child's own desire and curiosities. Vygotsky (1978) claimed that play experiences develop the whole child. Vygotsky (1978) also argued that pretend play could aid in the development of a child's ability to monitor and regulate his/her own behaviour to fit into the role being played. Schools that use the Reggio Approach allow children to experiment through hands-on learning and imagination play. Imaginative play in Forest Kindergartens is often more connected to the environment and eco-sustainability (Alcock & Ritchie, 2018). Purposeful play empowers students in their creative inquiries through autonomy, which by design makes learning engaging.

Creativity, Autonomy and Play in STEAM

As stated earlier, child-centered approaches play out differently in children's educational path than traditional models of learning. Furthermore, creativity, autonomy, and play are natural motivators in STEAM (science, technology, engineering, art, and math) education.

Rather than singling out each subject area and teaching it separately, STEAM curriculums use a natural approach to learning where multiple content areas are taught simultaneously (Hunter-Doniger, 2021a.). One benefit of this type of curriculum is that children can engage in transdisciplinary learning, which means there is a constant confluence and interaction as subjects enhance one another (Hunter-Doniger et. al, 2022). This is where creativity, autonomy, and play can really take shape. Children who are given the chance to explore like adults can feel as empowered as adults (Hunter-Doniger, 2020 & 2021b). In areas such as art and science, when children are given the chance to think for themselves and are free to investigate anomalies or points of interest that spark their curiosity, they tend to flourish (Hunter-Doniger, 2020 & 2021b). STEAM is a natural curriculum that embraces child-centered approaches to learning.

STEAM education gives children the opportunity to learn in new and creative ways and to problem solve. STEAM curriculum allows students to test out their ideas on real-world 21st Century problems. There are four major skills necessary for success in the 21st Century: critical thinking, communication, collaboration, and creativity (Darling-Hammond, 2010). These important skills are also known as the four Cs. Since STEAM is a holistic method of teaching that encompasses the concepts of creativity, autonomy, and play, the four Cs are a natural fit. They go hand in hand, giving value and meaning to learning that develops a motivation mindset. This can stimulate learning in multiple areas with boundless possibilities. Because STEAM education is based on a constructivist model of learning through hands-on engagement, it can inspire a sense of joy, engagement and eagerness to learn (Hunter-Doniger, 2021 a). In essence, STEAM education combined with child-centered approaches provides an environment where children can thrive.

Conclusion

It is with cautious optimism that I state that the proverbial educational pendulum has reached its crest and will soon swing towards a time when teachers and children have more say in the educational process. We have tried the factory model and scripted curriculums, so now it is time that we implement a pedagogical model that creates innovative thinkers and problem solvers. Rethinking the curriculum for children should consider the ubiquitous benefits of creativity, autonomy, and play found in child-centered models. This naturally taps into their interests and curiosities, pushing for deeper learning and empowering children to take an active role in their own learning process. Curriculum models like STEAM education can assist children to think and respond to multiple content areas at the same time. This provides them with opportunities to mull over concepts and formulate their own ideas, much like professionals like scientists and artist do in the real world.

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Hands-on Learning and Everyday Technologies in Finnish Preschool Education

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Starting from a very young age, technology plays a significant role in children's lives. This has created a need to define what technology education for young children is, and how it can be implemented in a child-oriented manner. The purpose of technology education in pre-primary education is to help children understand everyday technology and how it can be used to solve daily life problems (Fox-Turnbull, 2019; Sundqvist & Nilsson, 2018). One main goal of young children's technology education is to encourage children to observe technology and technological implementations surrounding them, and to evoke their interest in practical, hands-on ways. Working together, and inclusive, experimental and student-oriented activities are at the core of STEAM pedagogy. STEAM uses technology, natural sciences and art as approaches to learning self-direction, interaction skills and critical thinking.

In this article, with the help of some case examples, we will focus on what technology teaching is in Finnish early childhood education.

Technology Education in Finnish Preschools

Unlike in many European countries, Australia and New Zealand (Benson & Lunt, 2011; de Vries, 2018; Milne, 2018; Turja et al., 2009), technology education is not an independent subject in the Finnish school system. In primary education, *technology education is integrated as a part of crafts education* (FNBE, 2016), and in the preschool curriculum, technology education is a part of the "Exploring and interacting with my environment" learning module (FNBE, 2014, 40–42), together with mathematical content and environmental education.

In Finland, the main principles in young children's technology education are child-centered ways to act, use of imagination, and constructive play. Technology education in early childhood education means a wide-ranging content area that approaches technology practically from different angles, whereby children learn to observe the technology and technological phenomena around them. It has many common goals with other learning areas (FNBE, 2014), especially with crafts. Both of these learning areas include designing, creative problem solving, examining and experimenting with structures and materials, constructing or making, and reflecting on the process and products. Preschool technology education focuses on everyday machines, devices, electronics, information technology or robotics, or it can be related to housing or environmental technology (Yliverronen, 2019). Children are encouraged to figure out and build various constructions or solutions to their own, self-found technological problems using versatile materials, and to verbally describe their decisions (FNBE, 2014). At the same time, children acquire technological knowledge and exploratory learning skills (Yliverronen et al., 2021).

Starting from early childhood education, the teaching of crafts has a long tradition in Finnish schools. However, while certainly an element of it, neither specific work methods nor craft techniques have ever been at the essence of craft teaching. Rather, through working with craft materials, children practise their understanding of language of form, and math and science skills in a practical, everyday life context. When planning the visual and technical properties of the product to be manufactured and when considering their own operating process, they develop their design and process thinking skills, and their self-direction. It is essential to offer children the opportunity to invent, experiment and realise their own ideas, as their solutions and choices are part of the learning process. At the same time, children can practise shared responsibility and participation (Yliverronen, 2019). Furthermore, children´s visuomotor skills, which are pivotal for learning academic skills, are developed through concrete tasks (Grissmer et. al., 2010).

Synergies between inquiry-based and hands-on activities in early years science education have been highlighted in several studies (Lindeman et al., 2014; Park et al., 2016). Both approaches can be employed as tools for knowledge creation and learning, and both offer motivational support for promoting a positive attitude to science and creative ways of working (Stylianidou et al., 2018). Indeed, according to Roden (2015), it is almost impossible to separate some aspects of science, technology and craft education.

Young children's crafts and technology education form an entity, which offers different ways to implement learning modules, including inquiry-based and hands-on elements. The term *investigative activity* depicts young children's functional way of acting in a context of inquiry-based approach, where several objectives of early years education are integrated in child-centred way (Rönkkö et al., 2021). When learning activities are connected to experiences, children have the opportunity to wonder, explore, and experiment, as well as to ponder and recognise interesting phenomena. This is at the core of the way young children learn because they have a natural ability to ask and explore (Bulunuz, 2013; Vartiainen & Aksela, 2013).

Playful Elements and Investigative Activities

Young children´s learning is generally holistic. They learn by playing, moving, exploring, by working on different assignments, expressing themselves, and through activities based on arts (FNBE, 2014; Leong & Bodrova, 2012). Because of this, children are typically very interested in hands-on activities and small-scale investigations, such as observing daily live technological solutions and their functionality, examining phenomenon related to nature and technology, and making artifacts as a result of their experiences. Educators should enable children to implement their thoughts and investigations by preparing the tasks convenient to the children's age and skills and offering scaffolding during critical moments if needed (Reiser & Tabak, 2014). Preschool children's craft-making processes include the phases of experimental learning (Kolb, 1984) in proportion to children's age, where personal experience is based on reflective observation, perceiving, and active experimentation (Rönkkö & Aerila, 2015; Yliverronen & Seitamaa-Hakkarainen, 2016).

"Working together, and inclusive, experimental and student-oriented activities are at the core of STEAM pedagogy."

Investigative learning projects for young children can vary. For example, following the forming pattern on the surface of the fabric in solar dyeing or making a simple insect hotel can be a step for children to a broader consideration of natural phenomena. Alternatively, the observed natural phenomenon can be studied from different perspectives, where the phenomenon can be the starting point for the making of a craft product. Despite the technological abundance of today's world, for many young makers creating a pom-pom using cardboard discs and colourful threads has proven to be exciting - it has been like magic. Mixing reflective thread with the pom-pom thread and investigating in a dark room with the help of flashlights can add experientiality to the task. At the same time, children are able to consider issues related to light or traffic safety (Yliverronen, 2022).

Next, I will present two projects that approached technology education from different viewpoints.

Project One – Power Creatures

The first project, 'Power Creatures', an electricity-themed integrative learning unit in a munical preschool, is an example of a STEAM project that integrated technology education with art, design, and handicraft. Nineteen preschoolers, aged 5 to 6 years, participated in the project. The goals of the project were for children to learn the basics of everyday technologies in designing and making a felted craft product, and to develop co-operation skills, and to boost children's self-esteem through the joy of making. The project was implemented during a total of 20 sessions, approximately 30–60 minutes each, over a period of four months. The project began with an orientation phase, in which the teachers led the children toward the project's themes by reading storybooks related to the development of self-esteem aloud and by guiding discussion and play aroundelectricity and electrical safety (Rönkkö et al., 2021; Yliverronen et al., 2021).

Playful experimentation was used as a method for understanding the components and function of a circuit. In circuit play, the children held each other's hands, and one of them acted as a switch (sending an impulse), the second as a buzzer, and the third as a battery, while the rest of the children were conducting bodies. This gave the children the initial idea of a circuit, which helped them to build a real circuit with actual components after the play. In pairs, they constructed a circuit with batteries, a battery holder, a switch, alligator clips, and a buzzer. The children then experimented with various materials (i.e., furniture, walls, floors) to see if the material was conductive or nonconductive. After a short book introduction and various hands-on activities, the children were able to design and make fully-functioning circuits for their creatures. Further, the experiences supported them in understanding electricity and the function of everyday electrical objects (Rönkkö et al., 2021; Yliverronen et al., 2021).

The craft part of the project included the design of a ”Power Creature”, with children felting two pieces (front and back) for their creatures. With the help of eight grade students (aged 13–14), children then sewed a short circuit to their creature using conductive thread, adding a coin battery and LED lights onto the figure so that the product became an e-textile. Children then had the opportunity to reflect on their activities on Grandparents' Day, when they presented their characters. The children received positive feedback about their work, which is important for their self-esteem, and the grandparents helped the kindergarten staff to record the children's stories through the storycrafting method. Each child told a story about their creature, including what kind of powers it gives to the child, and how the powers can be used. The children acted as narrators, and the storycrafters, in this case grandparents, wrote the stories down verbatim (Karlsson, 2009; Rönkkö et al. 2021).

Design and ready-made ladybug with a LED light

Project 2 – Forest Animals' Nests

Design is a crucial aspect of creative technological activities because designing gives visual form to one's thoughts. Design can refer to visual design (i.e., shapes, colors, patterns), but it also can refer to technical design (i.e., structure, function, construction). Both of these aspects are important educational goals in young children's craft and technology activities, even though technical design is often difficult for novices.

Forest animals´ comfortable nest in a cardboard box.

The second project mentioned above involved preschoolers being given a task to collaboratively design and sketch forest animals' nests (Yliverronen et al., 2018). Craft making is traditionally seen as an individual execution, where makers are producing their own craft products, rather than a collaboration with shared outcomes. During this project, children were presented with the opportunity to experience shared design and making.

A total of 15 six-year-old pre-schoolers, randomly divided into four groups of either three or four children, took part in the project, which took place over five sessions of about 1.5 hours each. The groups were asked to decide which animals they would like to design nests for. The first task was to discuss ideas related to particular themes, such as how animals live in nature, and which items could make nests comfortable for them. From these discussions, children were asked to design convenient homes for forest animals and to draw their ideas on a sheet of paper from a bird's-eye view. To support their activities (Hope, 2008), children were encouraged to investigate and explore materials that were available for the designing task, including textile materials, package materials and materials from the forest (such as sticks, pinecones, spruce branches). The opportunity to investigate different kinds of construction materials helped the children to create more details for their plans. The concept of working collaboratively with peers to solve the given task was new for these children. The children not only had to imagine the result of the task without making the final product at the same time (Hope, 2008), they also had to verbalise their thoughts to the other group members, as well as find a way to work together as a team.

The main objective of the project in terms of data collection was to investigate the nature of preschool-aged children's collaboration during a designing task from the perspective of verbal and embodied interaction. The children's verbal collaboration was clearly focused on designing – they proposed ideas, developed ideas further, agreed and disagreed with proposed solutions, asked questions and organised their processes. The embodied interaction was focused on drawing, investigating materials, non-verbal participation like hand gestures, as well as playing around or other off-task activities. The results showed that preschoolers (6–7-year-olds in Finland) succeeded in working collaboratively and they managed to solve the designing task with their peers (Yliverronen et al., 2018). Afterwards, they built the forest animals´ nests in cardboard boxes based on the plans.

Discussion

Young children's designing and making are often intertwined, and their designs develop while they are making. Design discourse has the unique potential to support shared thinking processes and it gives a natural context in which to learn collaboration (Murphy & Hennessy, 2001). Opportunities for collaboration in STEAM projects should begin in early childhood education, because the activities provide a natural real-life situation in which to cooperate, negotiate and

finally create a common product with peers. Successful collaborative working sessions with peers offer natural ways for scaffolding and supporting deep understanding (Sawyer, 2006a). Peer support is seen as a system of giving and receiving he-lp with key elements of respect, shared responsibility, and mutual agreement of helpful activities (Mead et al., 2001). It is facilitated through a similar language between young people, and it gives the feeling of participation and school satisfaction (Mead & MacNiel, 2004). Furthermore, through hands-on activities, children can learn issues related to everyday technologies and demonstrate this learning in tangible, self-made products.

The project examples described above show the diversity of STEAM education. The objectives of the activity may vary in different situations, and different learning areas and working methods can be integrated into the STEAM implementation. It is extremely important to trust in children's abilities to solve the given task in their own way. Children's own implementation of the given task is the most valuable and instructive experience for them.

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STEAM for Sustainability in Early Learning and Care Settings: How KLABS4KIDS, a European Research Project, Aims to Support Teachers

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Snapshot from Practice

Picture it. A bright winter morning in an Early Learning and Care (ELC) setting. An educator and a group of six children aged 3-5 are sitting on the floor, hard at work building a bridge out of Lego. One child is measuring the distance between the bridge and the floor, another is building the stairs leading up to the bridge while his friend is taking photos of the mini building site with a digital camera.

At first glance, this may look unremarkable – a group of people playing with Lego – but in fact they are engaging in a complex engineering project. The educator has presented the children with a problem for which they, as a team, must endeavour to find a solution. The problem is that a family of cats need to cross the river to get to a party. They have limited materials and need to be mindful that crocodiles are circling the river and can lunge 15 cm out of the water. The bridge needs to be safe for young kittens, be strong enough to bear the weight of the cat family and keep them safe from hungry crocodiles.

After brainstorming together and sketching out some ideas, the children settle on a design for a prototype. They are now building the working model, which they will test, while gathering and analysing data. Based on their tests, they will make improvements on their design to ensure that the cat family can arrive at the party on time.

The benefits of this activity are clear. Through play and with the support of a skilled educator, the children have the opportunity to develop skills such as designing, creative problem solving skills, evaluating and analysing. These are only some of the core skills of STEM Education.

STEM Education

What is STEM education?

STEM education is an approach that veers away from compartmentalised teaching and learning. Instead it involves teaching Science, Technology, Engineering and Maths as an integrated whole, through everyday real life hands-on experiences (Bybee, 2010; Vincent-Lancrin et al., 2011).

Why implement STEM education in Ireland?

Ireland has a significant STEM skill shortage, with companies struggling to recruit engineers, animators, technical support staff, designers, software developers and crucial roles to support our society and economy (O'Dea, 2021). In relation to higher education, Irish universities award STEM degrees to only 24% of their graduates, a number that remains unchanged from the period 2010 to 2016 (cited in Des, 2017). In primary and secondary schools, Irish students' STEM performance is reported as average but significantly weaker than many high performing European countries (DES, 2017).

Why implement STEM education in Irish ELC settings?

To address the STEM skill shortage and to make certain that Ireland's youngest citizens have the opportunity to be active participants in society, the Department of Education and Skills (DES) published a STEM Education Policy statement that aims to make STEM education an integral part of the culture, policy and practice of our ELC settings and to make Ireland a leader in STEM performance by 2026 (DES, 2017).

The challenges

Degree level Early Learning and Care (ELC) programmes are designed to help graduates begin their careers with a wide range of knowledge and skills as well as a significant amount of fieldwork in early years settings. However, while learning through enquiry is an integral part of most ELC curriculum frameworks and degree programmes, undergraduates with maths and science anxieties can avoid these disciplines and still graduate. In 2018, a study from the United States (Spaen, 2018) found that some students enter into ELC programmes specifically to avoid science and maths. With these math and science anxieties unaddressed, the potential exists for them to pass them on to the children they are teaching and caring for).

Another pressing challenge is the Irish Early Years Sector's ongoing severe staff shortage (Early Childhood Ireland, 2021; Farrell, 2022). Early Years Educators are busy and asking them to revamp their programmes to incorporate STEM education is arguably unreasonable.

The support

Fortunately, any educator who consults the Aistear Síolta Practice Guide is most likely already presenting ample opportunity for children to develop STEM skills. The Practice Guide was developed to support parents and educators in developing loving and secure relationships with children so as to provide opportunity for learning through hands-on, open-ended, multisensory experiences (NCCA, 2009; CECDE, 2006). To extend learning and to enhance STEM experiences, parents and educators can incorporate the language of STEM into existing activities as well as familiarise themselves with core STEM skills to further develop their practice.

Resources

Many resources are available to support educators to enhance their STEM skills and weave them into their teaching practice. The following section will explore a research-based online toolkit that aims to help early years educators create opportunities for STEM learning by using the kitchen as a lab.

Kitchen Labs 4 Kids

Kitchen Lab 4 Kids is an international project, funded by the European Union within the Programme Erasmus+ Action 2. The project includes partners from Ireland, Poland, Italy and Spain. The partnership investigates the best pedagogical methods and explores existing projects within STEM teaching and learning in Early Childhood Education across Europe. The project seeks to ignite an international exchange of best practice and experience to promote the active learning of STEM disciplines in Early Childhood settings.

KLABS4KIDS highlights and addresses key issues for effective teaching of STEM at preschool level by collecting and producing resources for early years educators. On the project website http://kitchenlab4kids.eu, educators will find a structured toolkit with 100 learning resources that help provide STEM learning opportunities for young children using everyday materials from the kitchen.

Is it research based?

The KLABS partners carried out extensive and systematic research before creating a tool that meets the needs of teachers. The research study employed a mixed method approach, drawing on qualitative and quantitative data, to assess early years educators and student teachers knowledge, opinions and experience of teaching STEM skills using the kitchen a lab.

All partners organised focus groups and semi-structured interviews to gather qualitative data, to inform the development of a quantitative online questionnaire.

The findings, available on the KLABS website, show that, overall, teachers believe that young children are more than capable of solving scientific problems and participating in STEM workshops. All respondents confirm that STEM should be seen as a valuable part of pre-school education and be integral to the curriculum. The research points to reservations concerning teachers' confidence with STEM including safety, resources, time allowances, funding and support from management, however, no reservations from teachers about supporting STEM skills for very young children.

KLABS 4 KIDS tackles Sustainability

With the research based Kitchen Labs 4 Kids STEM skills Toolkit available and working, the partnership now focuses on Education for Sustainability (EfS) aiming to support ELC educators to enhance sustainability skills.

The project moves its focus from the kitchen to the outdoors as a laboratory and includes the Arts as an important component of education in the STEM disciplines, extending from STEM to STEAM. The researchers from Poland, Italy, Spain and Ireland endeavour to design and implement a research based repository of STEAM for Sustainability learning resources, a curriculum, a learning module for degree level students and a teachers handbook.

Before detailing how KLABS 4 Sustainability intend to support educators, this article will first explore the rationale, challenges and support already in place for sustainable development (EfS) in Irish ELC settings.

Why sustainability in Irish ELC settings?

In 2015, the UN General Assembly adopted the 2030 Agenda for Sustainable Development with its commitment to a plan of action for people, planet, prosperity and peace. The agenda addresses solutions for the man-made environmental challenges that face humanity. In alignment with the agenda, Ireland's National Strategy on Education for Sustainable Development was designed to make certain that the education system is contributing to the sustainability movement:

> *…equipping learners with the relevant knowledge (the 'what'), the key dispositions and skills (the 'how') and the values (the 'why') that will motivate and empower them throughout their lives to become informed active citizens who take action for a more sustainable future*

(cited in DES, 2017)

The agenda and the strategy include learners of all ages: babies, toddlers and pre-schoolers are capable competent citizens with rights (UNCRC, 1989) including a right to participate in society in a meaningful way. Considering the urgent worldwide debates and action concerning sustainability, the world's youngest citizens need to have their views heard and be made aware through the incorporation of EfS into their learning.

Challenges

Many educators may feel it counterintuitive to include young children in serious issues that some adults have difficulty understanding and addressing themselves (Gaziulusoy, 2020). Exposing children to alarming environmental issues at an early age and during a time when an increasing number of children haven't developed a personal connection with nature is not commensurate with supporting sustainability skills. As Sobel (1996) aptly puts it, 'If we want children to flourish to become truly empowered, then let us allow them to love the earth before we ask them to save it.'

The challenges in implementing STEM Education in ELC settings applies for EfS, that is, the absence of EfS training in Early Years undergraduate programmes and the staff shortage crisis .

Support

The good news is that early years educators who consult Aistear are most likely providing opportunities for children to develop Sustainability skills. UNESCO developed a framework of cross cutting key competencies for sustainability that is in alignment with the Sustainability Development Goals (SDGs) and necessary for all learners of all ages worldwide (UNESCO, 2017). When Aistear is mapped against UNESCO's cross cutting sustainability competencies, it is evident that there is ample opportunity for babies, toddlers and young children to gain all the key competencies, without overly alarming children with the catastrophic environmental possible futures that may await us (NCCA, 2018).

Resources

This section will revisit the KLABS project and its ongoing research that aims to support teachers and children in developing their sustainability and STEAM skills in outdoor settings.

KLABS4 Sustainability

As STEAM knowledge and skills help children better understand sustainability issues (Campbell & Speldelwinde, 2022), the KLABS4 Sustainability project implements a STEAM framework to promote the use of everyday materials from outdoor environments.

To ensure the design of resources fits the needs of teachers, the partnership starts to carefully develop a set of focus group questions to gather data from over 40 participants in Spain, Italy, Poland and Ireland.

The findings from the focus groups inform the design of the STEAM4 Sustainability Repository, which is a collection of resources around the seasons of the year, a familiar framework for teachers.

Rather than overwhelming and alienating educators, the repository meets them where they are in their STEAM and Sustainability knowledge and endeavours to build on existing practice.

In the winter of 2022, learning communities of students and educators in all four countries will trial the repository to determine the design of the STEAM4 Sustainability ELC curriculum, which will be completed by Summer 2023. The curriculum will also be tested by the learning communities and data collected will inform the design of a STEAM4 Sustainability learning module at Degree level and online professional development course for in-service teachers.

This research is ongoing but here is a taste of what a STEAM4 Sustainability in the Outdoors learning resource will look like in practice.

Picture it. A bright Autumn morning. A group of children aged 2 1/2 to 5 are walking around a section of the garden with their educator. They appear to be looking for something. One of the children picks up a slightly bent hoola hoop and asks the others 'What about this?' The others nod, one of them takes a photo of the hole hoop with a digital camera and they all keep looking around.

They are sorting through their "Restoration Yard", a section of the garden dedicated to materials that are waiting to be repurposed. The children and educator are looking for materials that they can use in their "Peace Path" project. The group follows the 6 steps of conflict resolution when conflict inevitably arises and they agree that it could be useful to have a designated section of the garden for conflict resolution, with a peace path that clearly shows the different steps for younger children. They have already found a site and settled on a design, now they are seeking to build what they need with what they have.

The benefits of this activity are clear. Through play and connection with a skilled educator, the children have the opportunity to develop skills such as anticipatory thinking, personal growth, discovering values, and flexible thinking. These opportunities encompass STEAM skills, sustainability competencies and outdoor education skills while addressing all pillars of sustainability: social, economic and ecological. Incorporating a Restoration Yard into the learning environment helps the children see how a circular economy that designs out waste and keeps materials in use is a sustainable practice as opposed to constant consuming and disposing. Furthermore, focusing on managing conflict helps the children learn how to build sustainable relationships and social skills. This kind of learning is already happening in ELC settings and the KLABS4Sustainability Project aims to support it and extend it.

Conclusion

To fully participate in our shared world, young children need learning opportunities that will help them develop STEAM and Sustainability skills. Bringing STEAM education and EfS to the core of our early years curriculums and communities can help ensure the best possible outcome for children. How we get there is equipping our teachers with research-based supports.

KLABS4KIDS is dedicated to supporting teachers so that they can teach and care with confidence, clarity and ease in the 21st century.

Visit **www.kitchenlab4kids.eu**
for more information.

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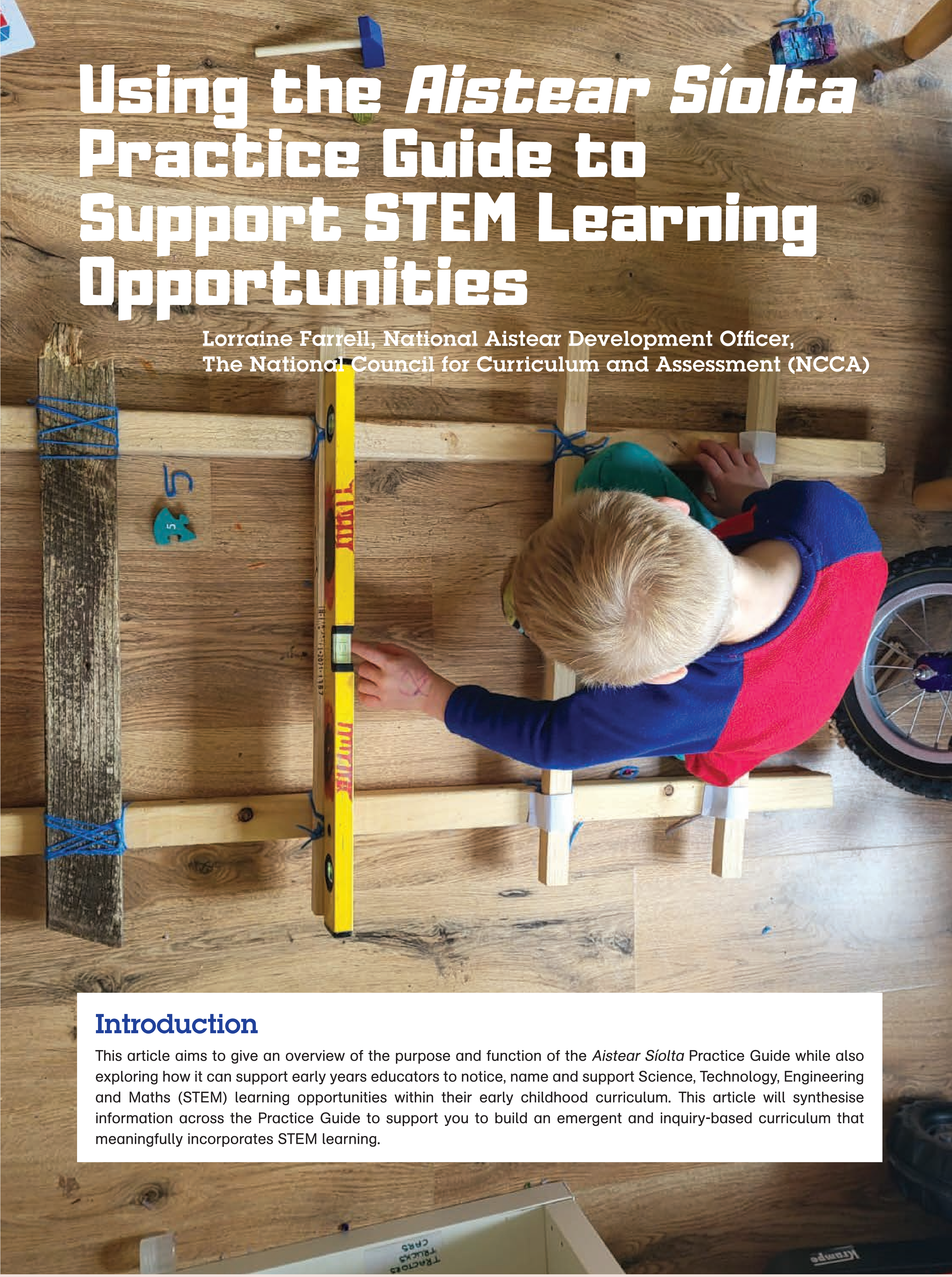

Using the *Aistear Síolta* Practice Guide to Support STEM Learning Opportunities

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Introduction

This article aims to give an overview of the purpose and function of the *Aistear Síolta* Practice Guide while also exploring how it can support early years educators to notice, name and support Science, Technology, Engineering and Maths (STEM) learning opportunities within their early childhood curriculum. This article will synthesise information across the Practice Guide to support you to build an emergent and inquiry-based curriculum that meaningfully incorporates STEM learning.

The *Aistear Síolta* Practice Guide

The *Aistear Síolta* Practice Guide[2] is an online tool to support early years educators in using *Aistear: the Early Childhood Curriculum Framework* and *Síolta, The National Quality Framework for Early Childhood Education* together to develop the quality of their curriculum and in doing so, to better support children's learning and development.

The Practice Guide offers suggestions, ideas, and examples of how the two frameworks can be used together to develop an early childhood curriculum. It is intended to help early years educators to build, reflect on and extend their curriculum to support babies', toddlers' and young children's holistic learning and development. Some resources in the Practice Guide, such as those that support STEM, focus on a specific age group—babies and toddlers (birth-3 years) and young children (3-6 years), while other resources are relevant across the full early childhood period (birth-6 years).

These resources include a range of materials to help early years educators to reflect on their curriculum and to identify what works well in a particular area and identify areas that might need some development. In this way, the Practice Guide can be used by individual educators, educators working collaboratively, and by educators being supported by a mentor for ongoing review, development and improvement.

The Practice Guide is made up of seven different sections and includes a section on Curriculum Foundations and six interconnected sections known as Curriculum Pillars. These include:

1. Building Partnerships with Parents
2. Creating and Using the Learning Environment
3. Learning through Play
4. Nurturing and Extending Interactions
5. Planning and Assessing using Aistear's Themes
6. Supporting Transitions

These pillars of curriculum development are intended to work together to support all areas of learning. The type of curriculum envisaged in the Practice Guide is responsive to all children and their different interests, backgrounds, and cultures. It emerges from the things, people, interests, and events in the environment, and from the issues that arise in the daily lives of those in the settings. Providing this type of curriculum based on *Aistear, Síolta* and the Practice Guide motivates, engages, and appropriately challenges all children as learners and enables them to progress in their individual learning journeys.

The Curriculum Foundations section of the Practice Guide is an important starting point when thinking about curriculum. This area is rooted in the principles, values and attitudes that shape each early years educator's work and that of the setting. Curriculum Foundations comprises an overview and four elements:

- Developing your curriculum and your curriculum statement
- Principles including the image and rights of children
- Themes of *Aistear*
- Professional practice

It is important that educators work on the first three elements of Curriculum Foundations before undertaking work on any of the Curriculum Pillars. Doing this will ensure that the setting is clear about what they are trying to achieve for children.

Pillars of practice

Curriculum Foundations are underpinned by six pillars of practice as listed above. Each pillar is made up of six sections – an overview, self-evaluation tool, examples and ideas for practice, resources for sharing, action planning tools and connections to relevant parts of the two frameworks.

2 Referred to as the Practice Guide throughout this article.

Building partnerships with parents

Aistear and *Síolta* highlight the important role parents[3] and families play in children's lives. Strong partnerships support all families but are especially helpful for parents in situations that may make it difficult for them to participate in their children's learning and development as much as they would like.

Creating and using the learning environment

Aistear and *Síolta* both highlight the impact that the environment, both indoors and outdoors, has on what and how children learn. Both frameworks also highlight the importance of daily outdoor experiences in all weather to promote children's learning and development and they acknowledge that a quality learning environment is challenging, stimulating, nurturing and everchanging. The two frameworks provide ideas and suggestions on how to create and use the learning environment effectively.

Learning through play

Aistear and *Síolta* highlight the important role of play in children's lives and provide ideas and suggestions to support learning and development through play. Play takes many forms and should be led by children's own interests and motivations. Play can happen inside or outside and evolves as children grown and develop. While playing, children are often exploring concepts and ideas related to the world around them or possibly consolidating existing or previous learning or practising a life skill.

Nurturing and extending interactions

Aistear and *Síolta* highlight the importance of interactions in children's learning and development in early childhood. Both frameworks provide ideas and suggestions on how to nurture and extend interactions to build quality relationships. They acknowledge that early years educators play an important role in building these relationships through consistent quality interactions. Babies, toddlers, and young children need a secure attachment to at least one of the early years educators in their setting. This person is known as their Key Person and is a familiar point of contact for parents and families. This relationship provides comfort, reassurance and security. Interactions that are respectful and consistent increase the child's confidence and competence to explore, develop and learn.

Planning and assessing

Aistear and *Síolta* highlight the importance of planning for and assessing children's early learning and development. Guided by *Aistear*'s themes, aims and learning goals, educators use a variety of methods to gather information to document children's learning and development. This material is recorded from different perspectives including that of children, educators and, at times, parents. This documentary evidence provides a rich picture of babies, toddlers, and young children as learners.

Supporting transitions

Aistear and *Síolta* highlight the importance of supportive and positive transitions in early childhood. The two frameworks provide ideas and suggestions on how to facilitate transitions in a sensitive, responsive, and thoughtful manner. A transition is the process of moving from one situation to another and taking time to adjust. Major transitions often represent significant milestones in a child's life and signify change for children and their families. The move from home to the first out-of-home setting is a very big milestone for children. Other types of transitions are more frequent, for example, the transition from one room to another in a setting, or from one activity to another during the course of a day.

3 Parents refer to the child's primary caregivers and educators. These include the father and mother and/or guardians (*Aistear*, Principles and Themes, NCCA, 2009, p.56)

Building STEM Learning Opportunities into the Early Childhood Curriculum

The third group of *Aistear*'s principles refer to how children learn and develop, and includes principles on holistic learning and development, active learning, play and hands-on experiences and relevant and meaningful experiences. These principles of early education are very pertinent to STEM learning, as is *Aistear*'s theme of Exploring and Thinking, which is about 'children making sense of the things, places and people in their world by interacting with others, playing, investigating, questioning, and forming, testing and refining ideas' (NCCA, 2009, p.43).

These principles and themes underpin the six pillars of the practice. These pillars are inter-related and often more than one pillar is highlighted in some of the support resources on the Practice Guide. An example of this is the recent addition of a suite of resources to support STEM education in early childhood settings. This suite of resources was developed in response to stakeholder feedback highlighting the importance of recognising and naming the opportunities for STEM learning in early childhood, and subsequently the publication of the STEM Education Policy (Department of Education and Skills, 2017).

As is evidenced in the Play pillar, *Aistear* and *Síolta* highlight the important role of play in children's lives and provide ideas and suggestions to support learning and development through play. Time, resources and support from educators all help children to maximise their fun in, and their learning and development through play, particularly child-led, hands-on play opportunities with natural materials. This type of play is fundamental to children's STEM learning where they have opportunities to explore, question and problem-solve. STEM education helps to develop skills like collaboration, creativity, critical thinking and communication.

Children's exploration, questioning and problem-solving through play and investigation underpin their development of basic concepts in STEM. Educators can support children's engagement with STEM by providing them with opportunities to solve problems, use their imaginations, ask questions, collaborate with others, experiment, make things and try different ways of doing things. Using natural and open-ended materials is one way to support this. Open-ended materials are materials that can be used in many different ways both indoors and outdoors by babies, toddlers and young children. They can be moved, carried, combined, and redesigned in any way the child decides. These materials can be natural or manufactured and the same item can be used differently by children at different stages of development.

Everyday practice provides plenty of opportunities for children to be involved in STEM learning with early years educators who notice and name the science, technology, engineering and maths learning that is happening . When early years educators think about STEM when planning for the children's experiences, they have the opportunity to identify the kind of language they will be using in their interactions with the children.

Supporting children's language development is fundamental to their overall development and, equally, using the language of STEM is a key role of the educator in promoting children's understanding of the world through a STEM lens. Early years educators noticing, naming and supporting children to understand and use the language of STEM can be achieved by introducing relevant vocabulary through everyday experiences, for example, block play, playing with water or sand, planting seeds or construction. Children's understanding of concepts is helped by becoming familiar with associated language. The challenge for early years educators is to be alert for, to recognise and respond to STEM moments during interactions with the children.

However, it is important to remember that children don't experience STEM in isolation. An interdisciplinary approach to including STEM in the early childhood curriculum is important so that the four disciplines of science, technology, engineering and maths are integrated into children's learning in a meaningful way. Children are innately curious about the world around them, and so are very natural explorers, engineers, mathematicians and scientists. Children learning by doing, so providing opportunities for them to tinker and freely explore the toys and open-ended materials around them allows them to experiment with the principles of STEM learning. Providing opportunities to experience STEM in early childhood promotes positive learning dispositions such as curiosity, concentration and perseverance while simultaneously developing important skills and strategies such prediction, critical thinking, creative thinking, reasoning, problem solving and analysing.

As noted earlier, children don't experience STEM concepts in isolation. For early years educators to fully understand the different aspects of STEM learning, it is useful to consider each of the elements individually and think about some examples of what STEM learning might look like in the early childhood learning environment and how it relates to the learning opportunities already available within the learning environment.

Science

Science in early childhood is about children discovering their world through the kind of play experiences that are provided every day in early childhood settings, both indoors and outdoors. Children often explore science concepts through their senses – tasting, smelling, listening, seeing and touching. Providing for sensory experiences that stimulate the senses will provide opportunities to discuss STEM concepts and introduce and reinforce STEM language. Talking about play experiences that support STEM learning, such as why strawberries only grow in summer and why there is a rainbow in the sky, is an effective and meaningful way to support children's interest in and understanding of the world around them.

Technology

Technology is all around us, and babies, toddlers and young children have regular experience of this. Technologies are tools or simple devices that have been made to meet human needs, so examples of tools that children might use are scissors, a magnifying glass, pencils or a printed book. As children get older, they may begin to experience digital technology such as digital cameras and voice recorders. These can be used in the early childhood learning environment to enable children to actively explore both indoors and outdoors using technology.

Children are exposed to many types of technology in their everyday lives from the time they are born. Automatic doors as you leave a building, paying for your shopping with your credit card or even your phone, hearing the washing machine beep to signal the cycle is done or even listening to adults speaking on the phone are all everyday technological experiences for children. Initially, children may not be active in these experiences, but they create the reality of their world. Roleplay scenarios that replicate these real-life scenarios and opportunities to play and explore within the curriculum offer children opportunities to experiment and understand how technology can be useful in helping us to do things we want to do.

Engineering

Engineering is about designing, making and building things. Open-ended materials are an effective way of supporting children to explore engineering in a safe and supportive environment. Examples of engineering in the early childhood learning environment involve constructing or adhering materials together. This might involve blocks, stickle bricks, playdough, art materials or sand, and could take any form such as building a train track.

Having conversations that give the children choices about what they want to use, for example, blocks, and what they want to create, or the shape the train track will take, supports them in forming and implementing their ideas. Educators who observe and listen to children talking about what they want to do with the materials provided, who encourage children to try out their plans, and talk with them about the results are fostering children's understanding of engineering.

Maths

Children are natural mathematicians and maths is everywhere in the world around us, think of pattern in nature such as butterfly wings, the stripes of a zebra, the pattern on a snowflake or the symmetry of an oak tree leaf. Much of children's learning about maths happens through exploration and play. Play, along with interactive story time and nursery rhymes, is a great opportunity for educators to help children to develop a positive attitude to maths, as well as a context for plenty of 'maths talk'. Because 'maths talk' is an important contributor to children's mathematical understanding, educators who use maths language accurately are supporting children's learning and development of maths concepts. Opportunities to develop and reinforce 'maths talk' occurs naturally while engaging in shop role-play, cooking and baking, and having open-ended discussion with children such as 'I wonder which car is heavier or can go faster' or 'I wonder why my tower keeps falling over'. Children's understanding about maths concepts such as number, shape and measure often comes from experiencing them and talking about them in their everyday interactions in the early childhood learning environment, both indoors and outdoors.

Conclusion

STEM is not a new area of education for babies, toddlers and young children, rather it includes a wide variety of learning experiences, supported by meaningful and engaging interactions with educators. It is likely that children are having STEM learning experiences every day in early childhood settings, underpinned by the principles and themes of *Aistear*. Through play with materials such as sand, water, playdough and in activities such as digging in the garden, climbing, and building with loose parts in the outdoors, children are making sense of the things, places and people in their world. These experiences are central to the development of an early childhood curriculum specific to the needs and interests of a particular group of children at a particular point in time. Using the *Aistear Síolta* Practice Guide will support early years educators in building this curriculum while also being cognisant of noticing, naming and supporting STEM learning opportunities on an ongoing basis.

There are lots of resources on the Practice Guide to help you with supporting and promoting STEM learning, including:

1. What is STEM? an information leaflet providing an overview of STEM in early childhood settings.
2. This is supported by a STEM Glossary explaining the different terms associated with STEM education.
3. We also hear from Dr Bridget Flanagan, an expert in STEM education, on supporting STEM in early childhood.
4. Following this, you may be interested in observing an early years educator supporting toddlers in their STEM learning through water play. Exploring STEM concepts: Water Play.
5. This video is further supported by information on supporting children's STEM learning experiences for Birth – 3 year olds and 3 – 6 year olds.
6. Other supportive resources include Using open-ended materials, Learning about measure, Supporting Mathematics and promoting positive learning dispositions.

Visit **www.aistearsiolta.ie** for a full overview of the supports available to support you in your role of early years educator.

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Titles Relating to STEAM Learning in Early Childhood

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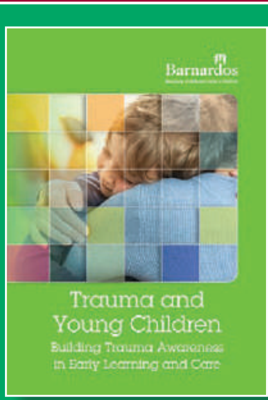

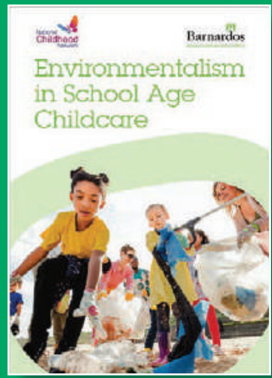

Training and CPD

eLearning - Children Learning in Natural Outdoor Environments

The aim of this new free elearning course from Barnardos is to encourage early childhood educators to reflect on the natural spaces and outdoor play experiences they provide and inspire them think about the ways they can make learning outdoors as intriguing and engaging as possible for young children. The course explores the value of connecting children with nature and outdoor learning, introduces a set of key outdoor play motifs that recognise and build on children's innate love of nature, offers guidance as to these principles can be used to enhance the quality of the outdoor environment and curriculum, and considers some important aspects of planning for natural outdoor experiences.

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