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# 'STEAM from the Start': Proposing a Conceptual Framework for the Development and Implementation of a STEAM Training Intervention for Early Childhood Educators

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## ABSTRACT

The benefits of STEAM, a transdisciplinary approach incorporating the areas of science, technology, engineering, arts and maths, for engaging learners, has been recognised internationally and increasingly forms part of educational policies both in Ireland and internationally. Although previous studies have demonstrated an increase in educator knowledge of STEAM post-training, these studies also highlight a continued lack of STEAM implementation in ECEC pedagogical practice. Through a review of existing national and international research, educational policy, best practice guidelines, and engagement with ECEC educators as participants, this phased research study utilises constructivist grounded theory to create a novel approach to STEAM training for ECEC educators. This new approach takes the form of a proposed *'STEAM from the Start'* conceptual framework, grounded in the experiences of ECEC educators. Designed to not only impart knowledge of STEAM and increase educator skill and ability, but also to support educators' confidence and belief in the value and importance of incorporating STEAM into their pedagogy. Therefore, aiming to increase educators' willingness and likelihood of incorporating STEAM into their ECEC pedagogical practice in the short, medium and longer term.

**Keywords:** STEAM, STEM, education, training, CPD, conceptual framework, early childhood education, constructivist grounded theory, constructive interpretivism, STEAM from the start, digital competence, basic skills

## INTRODUCTION

The world into which young children are born is continually evolving and swiftly becoming increasingly advanced and complex. For children to actively participate in their community and wider society, both now and into the future, it is important that life skills and dispositions are fostered through early childhood education and care (ECEC) which is 'future-oriented' (Organisation for Economic Co-Operation and Development (OECD), 2023, p. 117) and reflect those which are relevant to them as citizens of the 21st century (Wise Lindeman and McKendry Anderson, 2015).

Pedagogical approaches are increasingly adapting to facilitate children's development of valuable 21st century skills, such as critical thinking, collaboration, persistence, creativity and curiosity, in response to global change (Paniagua and Istance, 2018). Such adaptation will empower children as learners and citizens both now and in the future (OECD, 2023). Pedagogical STEAM interventions present children with the opportunity to develop such

knowledge, skills and dispositions necessary for global citizens living in a 21st century world (Jamil et al., 2017; Leavy et al., 2022; OECD, 2023). Furthermore, incorporating STEAM concepts in education, beginning in early childhood, has been highlighted by the European Union (EU) Commission (2025) as necessary to facilitate the development of fundamental basic life skills, including literacy, numeracy, science, digital competence, and citizenship.

However, numerous factors have been shown to impact on the successful incorporation of new pedagogical approaches, such as STEAM, in ECEC practice, including educator knowledge, training, self-perceived efficacy on the topic, and beliefs related to the new pedagogical approach (Hsiao and Yang, 2010; Greenfield et al., 2009; Kelchtermans, 2009; Tschannen-Moran et al., 1998).

This article will present ongoing research being undertaken to reconceptualise the integration of STEAM concepts in ECEC, through the development, implementation and evaluation of a STEAM training intervention for ECEC educators. Where previous research has developed STEAM training for ECEC educators based upon pre-existing models or conceptual frameworks, this paper proposes *'STEAM from the Start'*, a new conceptual framework for the successful integration of STEAM in ECEC educator training programmes. This research engaged constructive interpretivism and constructivist grounded theory to develop the *'STEAM from the Start'* conceptual framework which is grounded in ECEC educator's experiences regarding the barriers and facilitating factors which support or impede their incorporation of STEAM in pedagogical practice.

The following objectives were addressed within this study:

- Establishment of factors which facilitate and impede the integration of STEAM in ECEC practice.
- Exploration of educator pre-existing knowledge and beliefs regarding the definition and importance of STEAM.
- Development and implementation of a STEAM training intervention for ECEC educators and evaluate the impact on pedagogical practice in the immediate and medium term as indicators of the potential for long-term impact.

Results from a review of current relevant literature will be discussed below and includes research regarding the relevance of STEAM to children in the 21st century, the STEM gender gap, STEAM in educational policy, factors affecting the incorporation of STEAM in ECEC practice, the importance of providing STEAM training for ECEC educators, and the impact which educator beliefs regarding a new pedagogical approach can have on their incorporation of new approaches in their ECEC practice.

## LITERATURE REVIEW

### Relevance of STEAM in ECEC

STEAM interventions in the ECEC curriculum support children to develop skills which are immensely relevant to them as 21st century learners who will ultimately engage in the workforce of the future, a workforce which necessitates knowledge, ability and skills which are intrinsically linked to STEAM concepts (Jamil et al., 2017). Through STEAM interventions a skillset can be attained which is comprised of more than those which are traditionally associated with knowledge of the individual STEAM components (Murphy et al., 2019). Children will develop a wide-ranging set of skills which offer cognitive flexibility and adaptability, such as problem-solving, creativity and critical thinking (Bybee, 2013; Prinsley and Baranyai, 2015).

However, the value of children's engagement in STEAM interventions pertains to more than preparation for their future lives. Early access is important due to STEAM being posited as bound to children's sense of self-identity, owing to the significant degree to which it is embedded within their daily lives (Hachey, 2020). Children's attitude towards, and sense of identity relative to STEAM is formed in early childhood (Saucerman and Vasquez, 2014; Bowman et al., 2017; Marsh et al., 2017; Hachey, 2020), further compounding the importance of access to quality STEAM interventions within ECEC. Early exposure of young children to STEAM concepts, through meaningful, hands-on methods of engagement, has been indicated to positively impact the child's perception of, and dispositions relevant to STEAM (Bagiati et al., 2010).

### Addressing the STEM Gender Gap

Research maintains that societal stereotypes greatly affect the aspirational career trajectories of both men and women (Wood and Eagly, 2012; Fiske at al., 2002). Many assumptions exist which posit that advanced levels of cognitive ability, associated with terms such as *brilliant*, *gifted* or *genius*, are more frequently found in men rather than women (Upson and Friedman, 2012; Furnham et al., 2002; Kirkaldy et al., 2007; Lecklider, 2013). Such cognitive stereotypes have been suggested as a causational factor in the gender gap evident in many high-status careers (Leslie et al., 2015; Cimpian et al., 2015; Storage et al., 2016; Meyer et al., 2015). Similarly, gender stereotyping has been

 

shown to affect gender balance across STEM careers, for example, women's engagement in the mathematical field being impaired by an existing gender stereotype that men are better than women in this domain (Cveneck et al., 2011). In the Irish context, only one quarter of those engaged in fields regarded as STEM related are female, and this gender imbalance is also evident across Europe and the United States (Department of Education (DoE), 2022).

In recent years many initiatives have been undertaken to tackle this issue and to encourage more girls into STEM careers, however, such initiatives tend to target girls of primary and secondary school age, as opposed to extending into early childhood education. A recent *Survey of Female Students Attitudes to STEM* (I Wish, 2024) reports that, although there is an increase of female students undertaking university courses in the STEM areas, only 1 in 4 people working in STEM careers are female. Furthermore, this research reports that perceived barriers to STEM careers include poor gender equality, lack of information, and lack of confidence (I Wish, 2024). Such findings suggest that, despite access to initiatives to increase gender equality in STEM for primary and secondary students, barriers persist among this cohort. This researcher maintains that such initiatives need to begin earlier on the educational continuum, specifically in ECEC, before gender stereotypes related to STEM become embedded.

According to the United Nations International Children's Emergency Fund (UNICEF), ECEC has the potential to be gender transformative with the ability to break down barriers to equitable education and support the attainment of United Nations (UN) Sustainable Development Goal 4: Education. This is due to the unique position of ECEC to support the education of children just as gender identity begins to form, but before gender stereotypes become embedded (UNICEF, 2021) Research maintains that children develop a sense of their own gender by approximately 2 or 3 years old (Berenbaum et al., 2007), and by 6 years old children develop a perception of intellectual ability based on gender. In a study by Bian et al. (2017), girls of this age began avoiding activities they perceived to be for children who are *'really really smart'*, due to their lack of belief that children of their gender are *'really, really smart'*.

Engaging our youngest learners in STEAM, right from the beginning of the continuum of education, in ECEC, may help to address these gender gap issues and support equitable future access to associated career pathways in science, technology, engineering and maths (STEM) fields. However, this needs to be supported by focusing on STEAM in educational policy, reviewing ECEC curriculum frameworks and ensuring ECEC educators are appropriately trained to facilitate STEAM learning (Organisation for Economic Co-Operation and Development (OECD), 2023).

**STEAM in Educational Policy**

At European level, the European Commission's Union of Skills (2025b) and accompanying STEM Education Strategic Plan (2025) advocate for the integration of a STEAM focus in educational curricula beginning from early childhood. This approach is posited to foster the development of essential skills such as curiosity, creativity, critical thinking, and problem-solving. These competencies have been recognised by the European Union as critical for lifelong learning and indispensable for future societal and professional engagement. Furthermore, the EU Commission (2025) emphasises the importance of education that focuses on the development of fundamental skills, including literacy, numeracy, science, digital competence, and citizenship. STEAM education in early childhood education and care (ECEC) aligns with these priorities by providing a pedagogical approach which nurtures these basic skills. Such an educational focus is considered essential for personal development, employability, social inclusion, and active citizenship. The Action Plan on Basic Skills (EU Commission, 2025) is core to the European Commission Union of Skills and complementary to the associated STEM Education Strategic Plan (EU Commission, 2025a). Through proposals at European level, spanning the short- to medium- term, this action plan aims to support improved levels of basic skills development beginning in early childhood and continuing through to adult education, in addition to addressing the STEM gender gap (EU Commission, 2025).

Educational policy in Ireland has also placed an increased focus on children's development of competencies related to STEAM throughout their educational lives (Department of Education and Skills (DES), 2017a, 2017b). This is also recognised internationally within commitments made by the United Nations Educational Scientific and Cultural Organization (UNESCO) to support the attainment of commitments made under the Tashkent Declaration (UNESCO, 2022). One of these commitments pertains to the transformation of ECEC pedagogical approaches and curricula to support children to develop skills relevant to living in a 21st century digital world:

> 'Engage with the international community to harness scientific evidence and digital technologies to further transform curricula and pedagogy and to develop the skills children need in a rapidly changing and increasingly digitalised world in the absence of adequate progress on sustainable development' (UNESCO, 2022, p. 7).

However, despite an acknowledged importance of educational STEAM interventions, already recognised within EU policy (European Commission, 2025) and Irish educational policy at primary and post-primary level (DES

 

2017b), significant gaps in policy and professional educator training are impeding the incorporation of STEAM at ECEC level. A gap in the provision of quality STEAM supports for ECEC educators, to meet the needs of young children as they begin their life-long learning journey, has been acknowledged by the DES (2022). In addition, recommendations have also been made at European level to provide appropriate training to educators across all levels of the educational continuum on how to effectively integrated STEAM concepts into their pedagogy (Evagouru et al., 2024). This skills and knowledge gap must be appropriately addressed and resolved to provide equity in STEAM learning, and the attainment of associated skills, for children across the entire continuum of education.

**Challenges Impacting the Incorporation of STEAM in ECEC**

Integrating new concepts and methodologies linked to STEAM into ECEC pedagogy presents several challenges including knowledge, skill, beliefs and confidence. Understanding these obstacles is essential for developing effective STEAM training programs which can effectively address educators' needs and subsequently support the successful incorporation of STEAM concepts in ECEC practice.

Previous research has highlighted educators' knowledge, skills and belief in their ability to adopt and implement 'changing educational paradigms' associated with STEAM interventions, as a vital cog in the wheel to drive forward innovation in ECEC (Jamil et al., 2017, p. 416). Recent research from Papadakis et al. (2021) also identified educator confidence as a factor impacting incorporation of a new pedagogical strategy in their research on educational robotics. They maintain that appropriate knowledge and training in a new pedagogical strategy, such as robotics, is an important element in the development of educator confidence to implement the new approach (Papadakis et al., 2021).

The extent of educator's perceived level of self-efficacy, and belief in their ability and supporting knowledge to facilitate STEAM in the learning environment, have been demonstrated as directly impacting their pedagogical practice (Chen et al., 2021). Furthermore, the importance which educators place on STEAM, and the extent to which they believe in the value and importance of STEAM, have been highlighted in research as directly impacted by educators perceived level of knowledge, ability and self-efficacy (Burrows Borowczak and Slater, 2015; DeCoito and Myszkal, 2018). Additionally, if educators do not place sufficient value on the importance of STEAM, this has been shown to impact their inclination towards engagement with, and integration of, STEAM in their pedagogy (Margot and Kettler, 2019).

The impact of educator's perception of both their ability and knowledge pertaining to a particular subject matter has been cited as a significant barrier to the successful implementation of a new pedagogical approach (Tschannen-Moran et al., 1998; Greenfield et al., 2009). Such barriers may also present in relation to the establishment of STEAM interventions in ECEC as, if educators do not perceive themselves as sufficiently equipped with pedagogical knowledge of STEAM, they may be less likely to incorporate such STEAM interventions within their ECEC practice. In other words, a lack of training and knowledge may result in a lack of belief in the value of STEAM and the self-perception of the educator regarding their ability to facilitate STEAM. This is due to the impact which an individual's beliefs can have on their behaviour (Hsiao and Yang, 2010) and in the case of educators, beliefs serve as an aperture through which they both perceive and implement their professional role (Karakose et al., 2023; Kelchtermans, 2009). Pajares (1992) also maintained the impact of educator's attitudes and beliefs on their pedagogical practice:

> 'Few would argue that the beliefs educators hold influence their perceptions, and judgements, and in turn affect their classroom behaviour' (Pagares, 1992, p. 307).

Findings from a recent research study by Karakose et al. (2023) further underscores the extent to which perceived self-efficacy and attitude of educators can impact pedagogy. In their study of prospective mathematics teachers, Karakose et al. (2023) assessed the impact of educator self-efficacy on their teaching practice. They found increased levels of self-efficacy to be a crucial factor in effective teaching, a finding which could be extended to the context of educator self-efficacy to incorporate STEAM effectively in ECEC practice.

**The Importance of STEAM Training and CPD**

STEAM exploration is 'second nature for children' due to the possibilities for exploration and experimentation it offers (DeJarnette, 2018, p. 1), in addition to cultivating children's natural sense of curiosity, tendency for persistence and creative propensity (Banko et al., 2013), all of which are fundamental to the attainment of the child's knowledge of the world around them and support the introduction of STEAM concepts in ECEC. As children possess this intrinsic capacity to engage in STEAM, subsequently educators have an obligation to meet the educational needs of young children in this regard (Uğraş and Genç, 2018), an obligation which requires appropriate training and CPD. Existing research has highlighted the benefit of training and continuing professional

 

development (CPD) on educator ability to effectively incorporate STEAM within their planning and pedagogy (Brenneman et al., 2019; Monkeviciene et al., 2020; Cabello et al., 2021; Çiftçi et al., 2022).

Research to evaluate the impact of STEAM CPD for primary school teachers reported a positive influence on the participating teacher's ability to integrate STEAM in pedagogy following their engagement in a CPD opportunity (Velasco et al., 2022). Furthermore, teachers who were involved in a CPD programme reported an increase in their knowledge pertaining to STEAM correlating with an increased level of efficacy to incorporate STEAM in the learning environment (Nadelson et al., 2013).

Effective engagement in quality ECEC professional practice and associated pedagogy, necessitates an appropriately qualified and skilled educator. Intentionality behind STEAM experiences for young children in ECEC is an important contributor to the facilitation of STEAM interventions and requires the educator to have attained a foundational knowledge of STEAM concepts and related language (Chen et al., 2017; Johnston, 2019). To successfully incorporate and embed developmentally appropriate interventions within their pedagogical practice and curriculum approach, it is crucial that STEAM concepts are incorporated within educator training (Uğraş and Genç, 2018). However, this requirement for training to appropriately facilitate STEAM is not currently being met, with educators experiencing both a lack of resources and insufficient training required to enable them to facilitate STEAM within the ECEC pedagogical practice (Bagiati et al., 2010; DeJarnette, 2018).

Professional development is a critical component in empowering educators to effectively integrate a new approach, such as STEAM, into their pedagogical practice. Recent research studies maintain that targeted training and CPD can significantly enhance educators' confidence, proficiency and skill. For instance, in their study, Papadakis et al. (2021) illuminated the need for appropriate training programs to address barriers affecting educators' effective incorporation of robotics in pedagogical practice. Correspondingly, Karakose et al. (2023) demonstrated the impact of CPD to positively improve educators' self-efficacy and the subsequent positive impact on their teaching practices. These findings underscore the importance of CPD to ensure educators are well-equipped to implement STEAM.

In the Irish context, the importance of engaging in playful learning opportunities to develop STEAM knowledge and aptitudes, which can be afforded to children in ECEC, is also acknowledged. However, data simultaneously highlights a significant need to provide further supports, reinforced by policy, which would empower ECEC settings to engage with emerging national strategies on STEAM education (DoE, 2020). A 2020 report, published by the DoE, evaluating the implementation of STEAM related pedagogy in the ECEC, primary and post-primary education context (DoE, 2020) describes how background research underpinning the report managed to identify 'just one online CPD course directly related to the STEM Education Implementation Plan', a plan which was published by the DES in 2017. The report proceeds to describe how such CPD initiatives were 'required to bolster' pedagogy related to STEAM in ECEC (DES, 2020, p. 30). Furthermore, the DOE *STEM Education Implementation Plan – Consultation Report* (2023), maintained ECEC educators in Ireland were seeking professional development training and access to supports to enable them to develop their ability to incorporate STEAM into their practice.

The importance of ECEC educator training in this area is vital going forward and has been described as a necessary component, which must be addressed in programmatic review of ECEC educator initial training and ongoing CPD, to avoid a 'skills deficit' in this area (DoE, 2020, p. 36). If training is not appropriately provided, then it is less likely ECEC educators will incorporate STEAM into their pedagogy.

This research study aims to address this gap and reconceptualise the integration of STEAM concepts in early childhood education and care (ECEC) through the development, implementation and evaluation of a STEAM training intervention for ECEC educators.

## METHODOLOGY

### Research Design

This research engaged a mixed method approach. Creswell and Clark (2018) define mixed methods as research which combines both quantitative and qualitative methods. This approach supports triangulation, validity and reliability to the research and facilitates a deeper, more comprehensive understanding of the research problem through the collection, analysis and integration of both data types to harness their strengths and mitigate their weaknesses (Creswell and Clark, 2018; Almalki, 2016).

A constructive interpretivist paradigmatic approach, situated in constructivist grounded theory was also adopted in this research. Grounded theory was engaged as an inductive methodology to inform data analysis and subsequent development of a new theoretical approach to STEAM training for ECEC educators in the form of a new conceptual framework, which was subsequently named *'STEAM from the Start'*. This approach aligns with the

 

posited use of grounded theory for the creation of new theories which are grounded within, and identified through, an inductive analysis and interpretation of the data (Glaser and Strauss, 1967; Bryant and Charmaz, 2007).

**Theoretical Framework**

Earlier studies of note engaged existing theoretical frameworks to support the development of STEAM training for ECEC educators. For example, Jamil et al. (2017) utilised the **S**TEAM **C**lassroom **A**ssessment of **L**earning **E**xperiences, or SCALE model, proposed by Quigley et al. (2017). While a study undertaken by DeJarnette (2018) engaged a theoretical framework based on Sociocultural Theory (Vygotsky, 1978) and Constructivist Theory, which highlights the importance of linking learning with real life application and problem solving (Wilson, 1996). Although both studies reported an increase in educator STEAM knowledge and confidence, both also reported a dearth of post-training implementation of STEAM in pedagogical practice. Therefore, this research will propose a new conceptual framework for the development of STEAM training interventions, which is grounded in the data gathered regarding experiences of educator's barriers and facilitating factors impacting the incorporation of STEAM in their pedagogy.

**Constructivist Grounded Theory**

Constructivist grounded theory is a qualitative data analysis approach that derives meaning from participants' experiences, descriptions, and explanations to construct new theory. This method is particularly suitable when there is limited or no existing theory on the research topic. It involves an iterative process where data collection and analysis inform each other, allowing for the identification of new insights and meanings as the research progresses (Charmaz, 2024). This approach ensures that findings are grounded in participants' realities, enhancing the validity of the research. Reflexivity is integral to this process, requiring researchers to reflect on their assumptions, expectations, and choices, thereby influencing the creation of knowledge (Charmaz, 2014). Constructivist grounded theory acknowledges multiple realities and the positionality of both the researcher and participants, which impacts the design, analysis, and interpretation of data (Denzin and Lincoln, 2011, 2017). This method supports the development of new theoretical constructs that advance the research field.

By employing a grounded theory approach, this research aimed to develop a new theoretical framework to support ECEC educators to integrate STEAM into their pedagogy. Unlike previous studies, which relied on pre-existing frameworks and saw limited long-term implementation of STEAM, this study's methodology allowed for the creation of a new and novel approach. Constructivist ground theory was deemed to be the most appropriate methodology to positively differentiate this study from others and support educators' ability to integrate STEAM into their practice post-training and to continue to do so long-term. The researcher hypothesised that this methodological approach would ensure the efficacy of the STEAM training intervention developed and implemented as part of this study to positively influence ECEC educator pedagogy in the short, medium, and long term.

**Ethical Considerations**

Ethical approval for this research was sought and gained from the ethics review board at Dundalk Institute of Technology. To ensure ethical standards were upheld and informed consent was obtained, participants were provided with a comprehensive information leaflet and consent form in advance of their participation along with contact details for the researcher should they require further information. Perceived coercion was addressed by ensuring that participants understood that engagement in the research was voluntary, that confidentiality and anonymity were upheld and no identifying information was gathered. They were also informed of their right to withdraw from the study, should they wish to do so, without repercussion. No information was withheld from participants regarding the research purpose or procedure. Participants were notified of any potential risks, which were minimal, associated with this research, who would have access to the raw data, how it would be securely stored and when it would be destroyed.

**Sampling Strategy**

The sampling strategy engaged a combination of purposive and convenience sampling methods. Purposive sampling was initially used to identify early childhood educators who were appropriately qualified under Irish legislation and actively working in the ECEC sector. Convenience sampling was subsequently employed to select focus group participants from the initial cohort, allowing for a deeper exploration of the long-term effects of the training on ECEC practice. This approach ensured participants possessed the necessary theoretical knowledge and practical experience to contribute to the development of a new theoretical approach (Moser and Korstjens, 2017), such as that which formed the basis for the STEAM training intervention developed and implemented in this study.

 

Given the use of reflexive thematic analysis (RTA), the determination of sample size was not predefined, reflecting the iterative and interpretative nature of data collection and analysis in alignment with constructivist grounded theory. Unlike traditional methods that predefine sample sizes, this research adopted a flexible approach, collecting data until theoretical sufficiency and conceptual depth were achieved (Braun and Clarke, 2019; Nelson, 2016). Data saturation, where no new information emerges, was not the sole determinant; instead, the focus was on the quality and depth of data to develop a robust theoretical framework (Morse, 2015; Saunders et al., 2017).

### Analysing and Synthesising Data

Quantitative data gathered during this study was statistically analysed using Statistical Package for the Social Sciences (SPSS) Version 28.0 (International Business Machines (IBM), 2021) software. While qualitative data was coded and thematically analysed (Braun and Clarke, 2006). This mixed method approach afforded validity, objectivity and generalisability within both phases of the research. In Data Collection Phase 1 (DCP1) this methodology supported the establishment of a baseline regarding the current level of educator engagement in STEAM in ECEC pedagogical practice, the barriers and facilitating factors impacting educator engagement in STEAM in ECEC pedagogical practice, to begin understanding the research problem. Through analysis of both quantitative and qualitative data the researcher gained insight into what training interventions might be required to support ECEC educators to incorporate an increased level of STEAM in their ECEC pedagogical practice long-term and inform the development of qualitative questions for the focus group. In Data Collection Phase 2 (DCP2), this approach would also support objectivity, triangulation and validity within the findings.

Reflexive thematical analysis (RTA) (Braun and Clarke, 2022) was also engaged to support the researchers constructive interpretivism across the entire DCP1 data set and inform the development of a new conceptual framework, which would subsequently form the basis of an effective STEAM training intervention in DCP2. Reflexive Thematic Analysis (RTA), as developed by Braun and Clarke (2006, 2012, 2019, 2022), is a qualitative approach that immerses the researcher in the data through repeated engagement, allowing for the interpretation of deep latent meanings within thematic areas. This inductive process is described as organic, with the researcher acting as a resource to uncover meaning (Braun and Clarke, 2022, p. 236). RTA is particularly suited for qualitative research aiming for rich, nuanced data analysis, and when combined with grounded theory, it supports the development of new concepts grounded in participants' realities (Chapman et al., 2015). Reflexivity is central to RTA, requiring researchers to reflect on their assumptions, expectations, and choices throughout the research process, thereby influencing the creation of knowledge (Finlay and Gough, 2003; Braun and Clarke, 2022). Unlike positivist paradigms which emphasise coding reliability, RTA acknowledges that different researchers may interpret data differently and perceives this variability as a strength (Braun and Clarke, 2020; Byrne, 2021). This approach integrates the data, theoretical assumptions, and analytical skills of the researcher, aligning well with constructivist interpretivist paradigms and the development of the STEAM training intervention in this study (Braun and Clarke, 2019; Nelson, 2016). RTA would again be engaged in analysis of the entire DCP2 data set to interpret data and findings regarding the evaluation of the efficacy of the STEAM training intervention.

The engagement of constructivist grounded theory and constructive interpretivism resulted in an iterative approach whereby data was gathered, analysed and considered on a phase-by-phase basis as building blocks in development of the conceptual framework and STEAM training intervention, with data and findings from each phase informing the next. The researcher posited this approach would differentiate this study from earlier studies of note by ensuring the STEAM training intervention, developed in DCP2, would be firmly rooted in the needs and experiences of ECEC educators' relative to their implementation of STEAM in practice. To elucidate the study's iterative process, data collection methods, analysis, findings and discussion will be presented in order of the phases of data collection in the following section. At the time of writing, findings from the final stage are preliminary.

## DATA COLLECTION PHASE 1 – IDENTIFYING BARRIERS AND FACILITATING FACTORS

In DCP1 surveys and a focus group were undertaken, with qualified ECEC educators as the participant cohort, to provide a baseline indication of current barriers and facilitating factors impacting the incorporating STEAM in ECEC practice. A dissemination plan for the survey was drawn up listing the various professional channels which would be utilised for dissemination of the survey. These channels included higher education institutions, professional representative groups and their associated social media channels and national early childhood organisations. Survey participants were given the opportunity to express their interest in taking part in an online focus group which would be undertaken to provide additional, qualitative depth and richness to the survey data and a deeper understanding of the phenomenological experience of ECEC educators, while also affording

 

**Table 1.** DCP 1 – Focus group questions to establish barriers and facilitating factors to STEAM in ECEC practice

| No | Phase 2 – Focus group questions |
|---|---|
| 1 | What is your current role and qualification level? |
| 2 | What is your understanding of STEAM? |
| 3 | Can you describe your understanding and perception of technology? |
| 4 | Do you think STEAM is relevant in ECEC practice? |
| 5 | How would you describe your current level on knowledge on STEAM? |
| 6 | How do you feel about incorporating STEAM into your ECEC practice? |
| 7 | Do you feel any more or less confident with any of the individual STEAM domains? |
| 8 | What is your understanding of the role of the arts within STEAM? |
| 9 | Do you currently include STEAM in your pedagogical practice? |
| 10 | What training or CPD on STEAM have you engaged in, if any? |
| 11 | If participants experienced barriers to incorporating STEAM in their practice. |
| 12 | Participants opinions on STEAM training within initial educator training and CPD. |

triangulation and validity within the research. Data from this phase was coded and analysed, both statistically and thematically. DCP1 survey findings were utilised to inform the DCP1 focus group. Subsequently, the entire DCP1 dataset was analysed using RTA to inform development and implementation of the conceptual framework and STEAM training intervention in DCP2.

### DCP 1 – Survey Data

An online survey, comprising a mix of both open ($n$=3) and closed ($n$=17) questions, was disseminated to qualified ECEC educators currently working in the field. The responses from the survey ($n$=245) were then coded and analysed using SPSS software (IBM, 2021). Responses to qualitative questions were coded using both open coding and axial coding. Open coding was first utilised to identify similarity across responses which could then be grouped together. Axial coding was then engaged, and where connections were identified between the initial codes, they were grouped under identified categories. These categories were subsequently utilised, alongside categories identified during coding of the focus group data, to identify themes to support thematic analysis (Braun and Clarke, 2019) along with RTA (Braun and Clarke, 2022) of the findings across the entire data DCP1 set.

### DCP 1 – Focus Group Data

Focus group participants ($n$=6) were randomly selected from a pool of volunteers who had previously completed the DCP1 survey and indicated their interest in taking part in the focus group. The duration of the focus group was approximately ninety minutes and was facilitated by the researcher. Questions asked during the focus group were informed by the survey findings and included questions to establish ECEC educators experience of barriers and facilitating factors influencing the incorporation of STEAM in their pedagogy (**Table 1**).

The focus group took place on Microsoft Teams and was recorded (voice only) and subsequently transcribed. Qualitative data gathered during this phase was coded using both open and axial coding so that meaning could be found within the data at a deductive level. A process of open coding was initially utilised to identify similarities in the data across the responses which could then be grouped together. Axial coding was then engaged and, where connections were identified between initial codes, they were grouped under identified categories. Subsequently, the categories resulting from axial coding were used to support the identification of themes. Interpretation of the latent meaning within the thematic data was further analysed using RTA.

### DCP 1 – Findings and Reflexive Thematic Analysis

Visiting and re-visiting the data numerous times at this stage enabled the researcher to become familiar with the data, to delve deeper into the latent meaning contained within it, and to review and refine the themes for discussion (Braun and Clarke, 2022). A baseline regarding barriers and facilitating factors impacting ECEC educator's current implementation of STEAM in pedagogical practice was established through RTA of the DCP 1 survey and focus group dataset. Utilising RTA affords the researcher flexibility to interpretatively analyse data and extrapolate latent meaning to inform the production of new knowledge (Braun and Clarke, 2019; Byrne, 2021).

The process of RTA identified 6 themes impacting educators' incorporation and implementation of STEAM in ECEC practice which were named:

1. Importance of STEAM
2. Defining STEAM
3. (Mis)Perceptions of Technology
4. Training and CPD

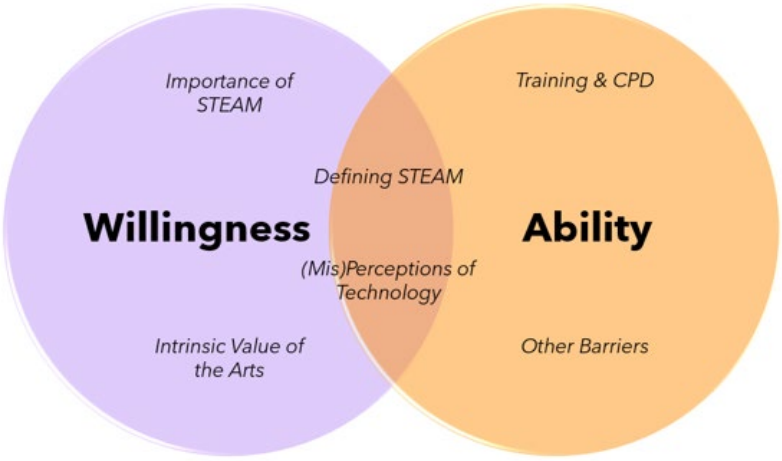


**Figure 1.** Identified themes linked to willingness and ability forces

5. Intrinsic Value of the Arts
6. Other Barriers

By engaging in RTA, the researcher can interpret the latent meaning within the data to endeavour to discover the meaning therein (Braun and Clarke, 2022). Through RTA and interpretation of the thematic findings, it was determined that the 6 identified themes implied there were two main driving factors directly impacting educators' integration of STEAM in their pedagogical practice.

As the 6 themes fell under either one or both of these factors (**Figure 1**), both factors would need to be appropriately considered and addressed in the development of a STEAM training intervention in DCP2, to support the successful incorporation of STEAM in ECEC practice post-training. The researcher named the two factors *'Willingness and Ability'* and posited that, addressing both factors would subsequently determine both how *willing and able* ECEC educators would be to integrate STEAM into their practice after their engagement in the training intervention during DCP2.

The researcher hypothesised this approach would address the gap remaining from previous studies, which, although showed a positive increase in educators understanding of STEAM and its importance in ECEC practice (which would align with the *'willingness'* factor), also demonstrated a lack of post-training implementation of STEAM in pedagogical practice, despite increasing their knowledge, indicating the *'ability'* factor for the incorporation of STEAM in ECEC was not sufficiently addressed. To increase the likelihood of long-term implementation of STEAM in practice, this researcher hypothesised that CPD training on STEAM must appropriately address both *'willingness and ability'* factors if STEAM practices are to make their way into ECEC pedagogical practice post-training.

### *Willingness and ability factors*

**Factor 1. Willingness**

It was the interpretation of the researcher that addressing findings within *Theme 1: Importance of STEAM* and *Theme 5: Intrinsic Value of the Arts* would influence how *'willing'* educators would be to incorporate STEAM into their practice after the training (**Figure 1**).

**Factor 2. Ability**

It was also the interpretation of the researcher that addressing findings within *Theme 4: Training and CPD* on STEAM and *Theme 6: Other Barriers*, which included factors such as money and time, would influence how *'able'* educators would be to incorporate STEAM after the training (**Figure 1**).

While some themes aligned clearly with either factor, it was the interpretation of the researcher that two of the themes, *Theme 2: Defining STEAM* and *Theme 3: (Mis)Perceptions of Technology*, straddled both the *'willingness and ability'* factors.

Theme 2: *Defining STEAM* is impacted by an educator's view of the *Importance of STEAM* (Theme 1), whether or not they acknowledge *the Intrinsic Value of the Arts* (Theme 5) and their engagement in *Training and CPD* on STEAM (Theme 4). While *(Mis)Perceptions of Technology* (Theme 3) is impacted by Theme 4: *Training and CPD* on STEAM, how educators view the *Importance of STEAM* (Theme 1) and Theme 6: *Other Barriers,* such as concerns around cost of materials or time for planning. Therefore, both *Defining STEAM* (Theme 2) and *(Mis)Perceptions of Technology* (Theme 3), impacted both the *'willingness and ability'* factors. For the STEAM training intervention within Phase 3 to be effective, all six identified themes would need to be addressed to ensure educators would subsequently be both *'willing and able'* to incorporate STEAM concepts into their pedagogical practice.

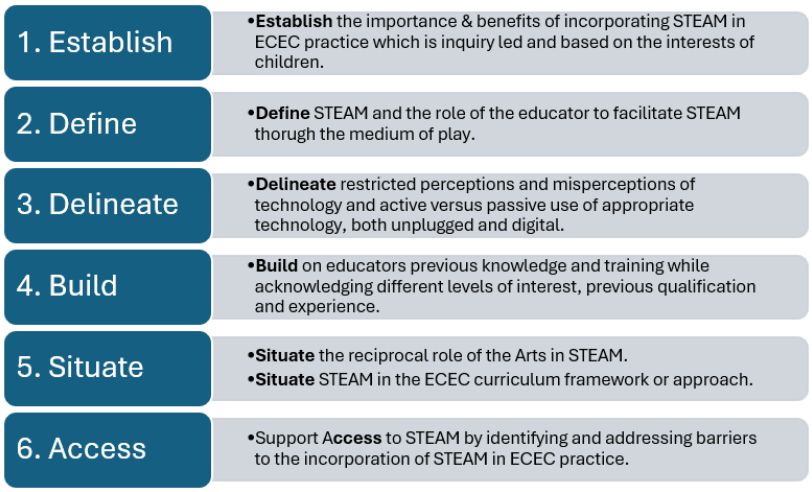


**Figure 2.** Proposed 'STEAM from the start' conceptual framework for the successful integration of STEAM in ECEC

In short, RTA of the DCP1 data indicated that numerous themes played a part in whether or not educators would be both *'willing and able'* to integrate STEAM into their pedagogical practice after engaging in the training. This approach formed the basis for development of the conceptual framework and STEAM training intervention which was developed, rolled out to educators and assessed for its impact during DCP2.

## DATA COLLECTION PHASE 2 – DEVELOPING, DELIVERING AND EVALUATING THE TRAINING INTERVENTION

The realities of participants phenomenological experiences of barriers and facilitating factors impacting their implementation of STEAM in practice, ascertained in DCP1, formed the cornerstone in the construction of DCP2. A proposed conceptual framework (**Figure 2**) for the successful integration of STEAM in ECEC was developed, based on DCP1 findings, and formed the basis upon which to construct the DCP2 STEAM training intervention and associated lesson plans.

### DCP 2 – Proposing the Conceptual Framework

As outlined in **Figure 2**, the proposed conceptual framework, entitled *'STEAM from the Start'*, is comprised of 6 points. Each point is directly linked to one of the 6 themes identified in DCP1 and either one or both of the *'willingness and ability'* factors (**Figure 3**). Embedding each point on the proposed conceptual framework in the design of a STEAM training intervention would address the 6 thematic areas and therefore the *'willingness and ability'* factors, which DCP1 findings had shown to be determinants regarding educator's incorporation of STEAM in their practice.

It was the hypothesis of the researcher that, by addressing each point on the framework during the development of the STEAM training workshop, the likelihood of the educator's integration of STEAM into their current and future practice post-training would be increased, therefore making it more effective than training which focusses on educator ability or willingness alone, and therefore be a positive point of difference between this study and previous studies.

### DCP 2 – Development of the STEAM Training Intervention

When developing the STEAM training intervention, each point on the proposed *'STEAM from the Start'* conceptual framework, informed a learning outcome which would be addressed as part of the training and within the associated lesson plan. This would ensure all topics covered in the training intervention could be directly traced back to the proposed conceptual framework, and therefore to the 6 themes identified within the DCP1 data of this research, as the mind map in **Figure 4** illustrates. Consequently, the researcher could be confident that the STEAM training intervention was grounded within the DCP1 data and the phenomenological STEAM experiences of the ECEC educator participants, and as a result, aligned with the both the constructivist interpretivist paradigmatic approach and constructivist grounded theory methodology. A universal design for learning (UDL) approach was also adopted by the researcher during this phase. This approach was taken to eliminate potential barriers to learner engagement and avoid a '*one-size-fits-all*' approach by endeavouring to meet the needs of individual learners and empower them to engage in the learning in a meaningful way (Center for Applied Special Technology

 

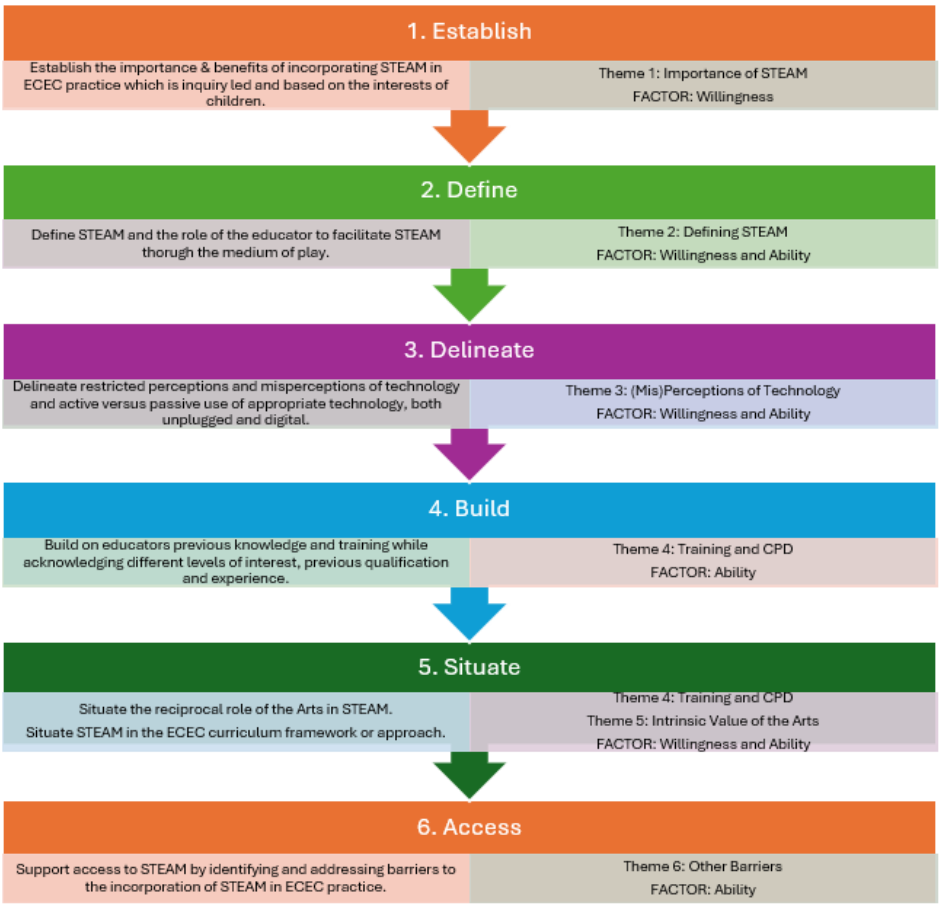


**Figure 3.** Links between proposed 'STEAM from the start' conceptual framework, identified themes and willingness and ability forces

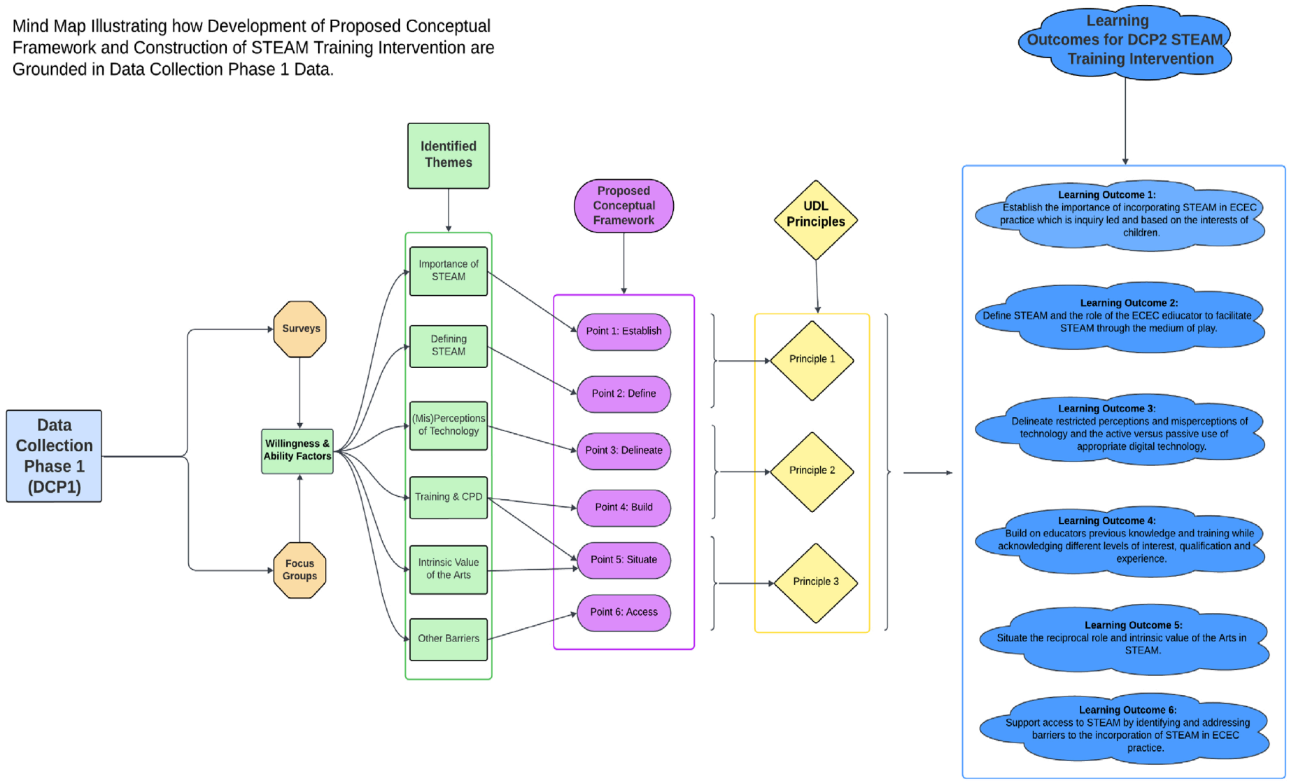


**Figure 4.** Training conceptual framework and learning outcomes to themes identified in data collection phase 1

(CAST), 2011). The incorporation of UDL principles in the design of the STEAM training intervention is also illustrated in **Figure 4**.

**Table 2.** Questions addressed during DCP 2 – Post-training focus group

| No | List of post-training focus group questions |
|---|---|
| 13 | Why did you engage in the STEAM training workshop? |
| 14 | What did you find most and least useful about the training? |
| 15 | Since taking part, have you implemented any of the activities/strategies from the workshop in your practice? |
| 16 | Did any aspect of the training concern you in any way? |
| 17 | Did the training have any impact on your opinion or perception of STEAM in early childhood practice? |
| 18 | Has the training had any impact on your confidence to implement STEAM in practice? |
| 19 | What is your opinion on the structure of the workshop? |
| 20 | Did the theory component of the training impact your perception of the practical component? |
| 21 | What further support would you find useful after engaging in the training? |
| 22 | Have you shared anything in particular which you learned during the training with colleagues? |
| 23 | Do you think the training had any impact on your perception of technology for early childhood practice? |
| 24 | Have you implemented any STEAM activities in practice since the training, other than those you learned in the training? |
| 25 | Do you think you have approached activities differently since the training? |
| 26 | Has STEAM become more prominent in your planning since the training? |

### DCP 2 – Delivery of the STEAM Training Intervention

A total of 13 STEAM training workshops were undertaken nationally and attended by 153 participant educators in conjunction with national early childhood organisations including local County Childcare Committees (CCC's), the National Childhood Network (NCN) and Barnardos. Each workshop comprised of 2 parts, the first being a classroom style approach and the second part involving experiential learning through hands-on, interactive engagement with STEAM resources and materials. This approach would ensure participants would gain the appropriate theoretical knowledge and practical experience to address the *'willingness and ability'* factors required to support future integration of STEAM in their pedagogy, as was found to be important in the RTA of the data from DCP1.

To establish the efficacy and effectiveness of the workshops on educator's *willingness and ability* to integrate STEAM, participants ($n$=153) were asked to undertake a pre- and post-training survey on the day of training. Furthermore, approximately two months after the workshop, 2 focus groups were undertaken with a small number of participants ($n$=7) from the training cohort to endeavour to establish the potential long-term effect of the training on ECEC practice. Focus group participants were randomly selected from a pool of volunteers who had completed the STEAM training workshop and indicated their interest in taking part in the focus group. Questions asked during the focus groups were designed to establish the impact of the design of the workshop, the impact of the workshop on ECEC practice and to identify future areas for improvement or post-training support for educators to support their future pedagogy (**Table 2**).

All training materials, including slideshow, materials and resources, post-training STEAM booklet and certificate of participation for all participants, were provided by the researcher. The STEAM booklet and certificate of participation were provided in downloadable pdf form for sustainability purposes.

### DCP 2 – Preliminary Findings and Discussion

Although preliminary, findings emerging through initial statistical analysis and early RTA of data from DCP2 post-training surveys and focus groups are indicative of a positive impact on the immediate and medium-term pedagogical practice of the participant ECEC educators who engaged in the STEAM training workshop.

#### *Increased knowledge and confidence*

When asked in the post-training survey about the impact of the workshop on their knowledge of STEAM, 100% ($n$=142) of those who responded to this question reported some increase in their level of STEAM knowledge immediately following the training, with 59% of respondents ($n$=84) citing a significant impact and 28% of respondents ($n$=40) citing that their knowledge had increased a lot (**Figure 5**). Furthermore, 94% of respondents ($n$=137) reported feeling more confident in their ability to provide STEAM experiences for children in ECEC (**Figure 6**) and 97% of respondents ($n$=140) reported thinking that engaging in STEAM was more important for ECEC children after the training (**Figure 7**).

Additional triangulation and validity are afforded to these preliminary findings through initial RTA of data from the DCP2 focus groups with educators, which took place approximately 2 months later, describing their increased knowledge and continuing confidence resulting from the workshop:

> '…after doing the STEAM (training), I felt that we could do more'. (FG1, Participant 1).

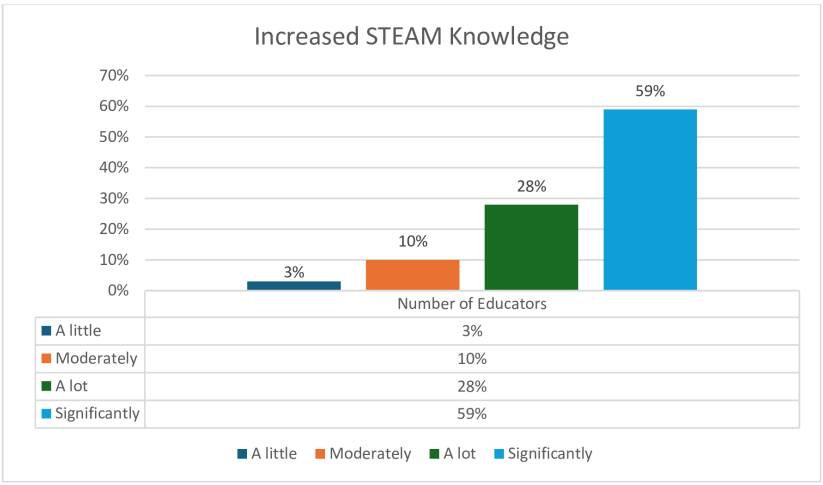


**Figure 5.** Number of educators who reported an increase in STEAM knowledge

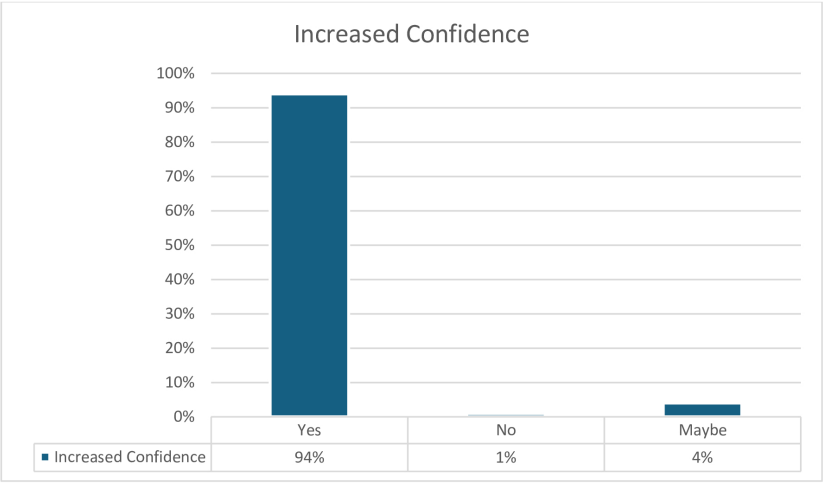


**Figure 6.** Percentage of educators who reported an increase in confidence

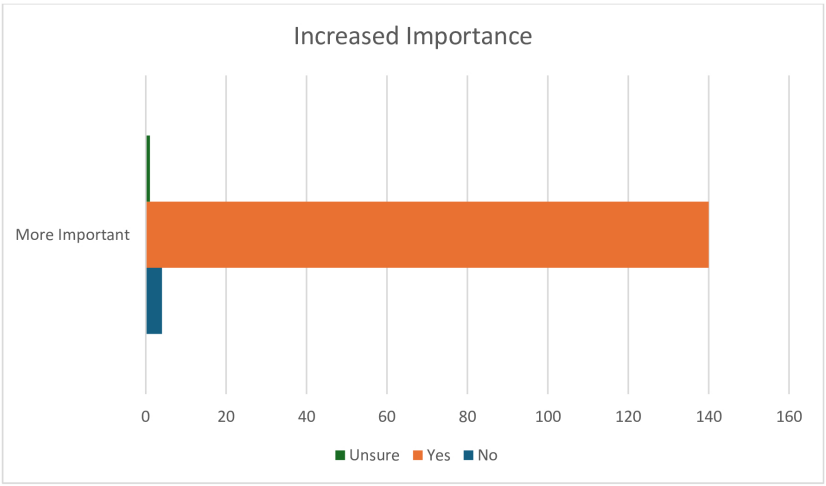


**Figure 7.** Number of educators who thought STEAM in ECEC was more important after the training

> 'So now instead of just doing an activity we're like, 'Where does this place?', you know 'Where is it in science? Where is it in technology?' (FG1, P1).

> '… it opened up my idea of the understanding of STEAM, I mean I had an idea of what it was. But it filled in more the gap … made me realise … it's something you do every day. It's in everything' (FG2, P1).

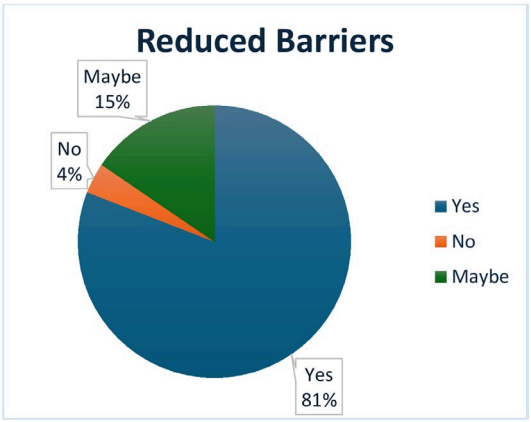


**Figure 8.** Percentage of educators who reported a reduction in their previous perception of barriers to STEAM

### *Reduced barriers*

In the DCP2 focus groups participant responses indicated a reduction in perceived barriers to STEAM two months post-training. Some participants described how their concern over the incorporation of technology within their practice had abated after the training:

> '… in the beginning of the workshop I was just worried about the term technology … in my head technology meant only like screen time … and that was gone then after we did the workshop' (FG1, P2).

While others described how they now recognised that they did not require expensive materials and equipment to incorporate STEAM in their practice:

> '… now I recognise that STEAM can be used with natural objects, things collected in the garden, the recyclables…we have everything there at our fingertips. It's just how we use it, isn't it?' (FG2, P2).

The important impact of the training on educator's beliefs regarding their ability to facilitate STEAM activities was also evident:

> '… only barrier is in your mind...but if you are open minded you will, you'll figure [it] out…' (FG2, P3).

These preliminary qualitative findings offer validity to the quantitative findings from the post-training survey whereby 81% of respondents ($n$=89) who felt that barriers had previously impacted their ability to incorporate STEAM reported the training had reduced their perception of such barriers (**Figure 8**). When considered in combination, the focus group and survey findings indicate educators experienced a reduction in their perception of barriers to STEAM immediately after the training and this was sustained two months on.

### *Short-, medium- and long-term impact on practice*

An important aim of this research is to establish the potential impact of the developed STEAM training intervention on long-term pedagogical practice. A positive finding in this regard would differentiate this study from previous studies.

The preliminary analysis of the DCP2 data is indicative of potential for long-term positive impact on pedagogical practice. Post-training surveys to assess the immediate and short-term impact of the training indicate positive results, with 98% ($n$=139) of respondents reporting being likely to incorporate more STEAM into their pedagogical practice after the training. 88% ($n$=125) said they were very likely and 10% ($n$=14) said they were somewhat likely. These early results indicate an immediate and positive impact of the workshop (**Figure 9**).

When the DCP2 focus groups were undertaken, approximately 2 months post-training, to endeavour to establish the medium-term and potential long-term impact, participants responded that they had implemented some of the strategies they had learned at the training in their practice, were continuing to consider STEAM more during their planning and were also continuing to incorporate more STEAM in practice as a result of engaging in the training:

> 'I definitely think more of putting STEAM into it' (FG1, P3)

> '… I have included more resources and more time to it' (FG2, P2).

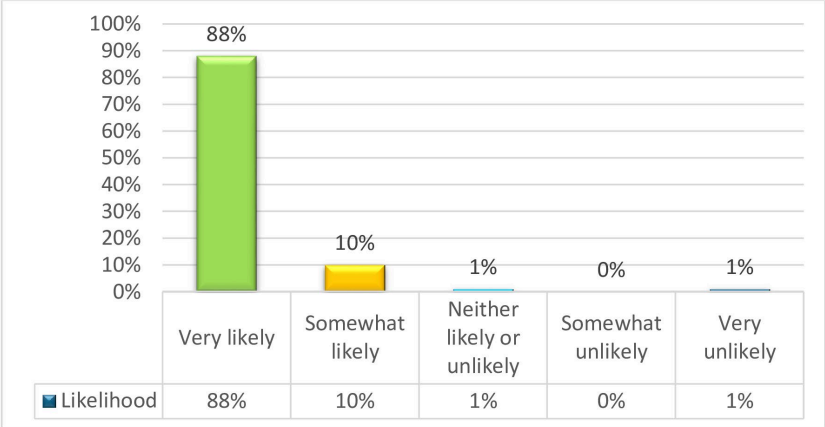


**Figure 9.** Educators' likelihood of incorporating more STREAM into pedagogical practice after the training

> '… taking those moments and seeing those opportunities where I could enhance the language around STEAM I have implemented since then' (FG2, P3).
>
> 'I'm thinking about it more that this is STEAM, I don't know. Yeah, I think I just know that I'm doing it more' (FG1, P3).

## CONCLUSION

This research utilised constructive interpretivism and a constructivist grounded theory approach to construct and propose the *'STEAM from the Start'* conceptual framework. This new conceptual framework formed the basis for development of a STEAM training intervention rooted in the interpretative exploration of educator's STEAM knowledge and beliefs along with their experiences of facilitating and impeding factors impacting their incorporation of STEAM in ECEC practice. Each phase of this iterative study inductively informed the following phase. Although current findings are preliminary and emergent, they suggest the approach taken within this research positively differentiates this study from earlier studies in terms of post-training impact on practice. This was achieved by developing STEAM training, based on the newly proposed conceptual framework, which was specifically designed using constructivist grounded theory and therefore rooted in ECEC educators' experiences of barriers and facilitating factors affecting both their *'willingness and ability'* to incorporate STEAM into their pedagogical practice going forward.

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