

# STEM Play & Learn: A Summer Family Learning Programme in Socio-Economically Disadvantaged Communities

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**Abstract -** *This innovative practice full paper describes a home-based summer family learning programme, STEM Play & Learn, designed to support kindergarten-aged children and their families by engaging them in Science, Technology, Engineering and Mathematics (STEM) activities. ‘Summer Learning Loss’ is the phenomenon where children experience a decrease in academic knowledge and skills when they take an extended break from education, particularly during the summer holidays. Children from lower socio-economic status backgrounds are disproportionately affected by summer learning loss. This research investigates the efficacy of a novel STEM Summer Family Learning Programme for 4–6-year-old children in a socio-economically disadvantaged community. The novelty of our programme centres around the practice and pedagogy delivered in the child’s home with parental engagement at its core. The programme is delivered once a week over six weeks by Home Visitors. Child-directed open-ended play-based STEM activities are modelled to encourage children to develop higher-order thinking skills. Parents and children are encouraged to explore these educational STEM Play and Learn activities further between visits. Through a community action research methodology, this research employs a cyclical process of observing, reflecting, acting, evaluating, and modifying. Results of parent and child evaluation data show promise in improving the children’s developmental skills and positively influencing the home learning environment. Results also indicate there was an increase in the parents’*

*confidence in teaching their children STEM at home. The findings contribute insights into how an innovative STEM family learning programme for early years educators and parents enhances educational outcomes for kindergarten-aged children and mitigates summer learning loss.*

**Key Words -** *Diversity and Broadening Participation; Informal Learning Environments; Pedagogical and Instructional Approaches; STEM; K-12 Education*

## I. INTRODUCTION

Children have been found to experience a decrease in academic knowledge and skills when they take an extended break from education, particularly during the summer holidays. This phenomenon is known as ‘Summer Learning Loss’ [1]. Children from low-socioeconomic status (low-SES) families are disproportionately affected by this phenomenon [1][2][3][4]. Several factors contribute to low-SES children’s summer learning loss such as reduced exposure to stimulating learning experiences, lack of practice and reinforcement of academic skills and reduced engagement in academic activities [1]. On average, low-SES children experienced a loss equivalent to one month of school year learning [1][4]. Summer enrichment programmes and targeted interventions for low-SES children are a potential solution to combat summer learning loss [2]. However, to avoid overload and burnout for children, summer programmes must balance enrichment and relaxation [5].

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Research consistently highlights early learning as being the foundation for all subsequent learning [6] and the importance of STEM as an indicator of future academic success [7]. Introducing STEM learning experiences to children in early childhood supports later learning in numeracy and literacy [8]. Play-based STEM education is known to tap into children's natural inclination to explore and experiment, providing hands-on learning experiences that enhance critical thinking, creativity, and abstract reasoning skills. Children develop STEM understanding through interacting with their everyday environment in curiosity-driven ways, often with support from teachers or other adults like their parents [9]. Afterschool and summer programmes have emerged as key contributors to advancing STEM education for children and young people [10], particularly for low-SES students [11]. Such Programmes need to begin as early as age three as the first few summers are the most crucial in retaining basic knowledge and skills [12].

Play is the work of childhood [13]. While there are gaps in the investigation of play-based learning, research continuously highlights its importance for children's cognitive development [14]. *Aistear, Early Years Curriculum Framework* [8], which aims to promote children's growth and development through play and exploration, provides guidance and support for early years educators to plan, deliver and assess enjoyable and appropriately challenging learning experiences for young children. Along with *Siolta, The Quality Framework for Early Childhood Education* [8], its reflective assessment and planning for learning, based on children's needs, culture and interests, supports the delivery of high-quality early years programmes [15].

Parents play a critical role in structuring a child's environment influencing the activities and materials they engage with while ultimately supporting their learning [16][17]. This environment provided by parents is known as the home learning environment (HLE). High-SES parents generally have greater access to resources and knowledge to help their children successfully engage in education at home. They understand and model the skills and behaviours instrumental in providing a positive HLE. Low-SES parents generally want the same kinds of enriching experiences for their children, however, do not have the same opportunities to access the resources and knowledge [18]. Educational intervention programmes for low-SES families are necessary to model to parents how to improve home-based parent-child interactions and provide a high-quality home learning environment. For these programmes to be successful, they need to address the parents' practical barriers in time, knowledge, finances, and other factors [19]. Quality learning environments, qualified teachers and parental engagement are critical factors in enhancing children's early educational experiences [20].

This research aims to investigate the efficacy of a six-week STEM Summer Family Learning programme for 4–6-year-old children in a socio-economically disadvantaged community. The major contribution of this research is a novel home-visiting Family Learning Programme called STEM Play and Learn, grounded in Aistear [8] that combines Curriculum Planning, Home Visitor Training, Family Recruitment, Process Referrals, Intake and Allocations: Pre-Programme Survey, 6-week Programme Implementation & Data Collection, Post-Programme Survey, Data Analysis & Review. Efficacy is defined as the combination of 4 dimensions namely, Parent-Child engagement, including an increase in home learning activities, Parent-Child satisfaction and impact, children's learning outcomes, in particular literacy, numeracy, language, and social-emotional development, fine motor skills, and finally Parents' STEM literacy, confidence, and perceptions. The key research question is whether the programme addressed summer learning loss by engaging families in more home-learning STEM activities, improving children's STEM skills and developing parents' confidence in supporting their children's STEM learning.

## II. RELATED WORK

Summer learning Programmes for low-SES children have shown to be successful with [21] illustrating results from a summer programme that enrolled 175 students. There was an average daily participation of 140 students over four weeks. A voluntary sample of 112 students completed pre- and post-assessments across science, math, and reading subjects that showed successful results. Additionally, a study involving 22 low-SES elementary students evaluated a summer programme aimed at enhancing oral and written narrative skills. Oral and written narrative samples were collected before and after the programme, along with weekly curriculum-based assessments. Results demonstrated significant improvements in narrative abilities [22] with programmes designed to meet specific students' needs, and that link their content to desired student outcomes and cultures [23].

Early Learning Initiative (ELI) at the National College of Ireland (NCI) is a community-based initiative working in partnership with parents, local schools, and services to deliver educational programmes in the most disadvantaged areas of Dublin's Inner City and across Ireland. STEM Home Visiting and Family Engagement programmes have been running in partnership with parents since 2007 [24]. These programmes range from weekly home visiting, and once-off STEM events to 8-week-long coding clubs, all centred around introducing STEM skills to children in a fun environment [25]. ParentChild+, an innovative home visiting programme that strengthens families and prepares children to succeed academically, is delivered to at-risk families with children aged 18 months to 3 years by Home Visitors. Trained and employed by NCI, they are all local women, many former participants of the programme who are ambassadors for education in the community. Twice

weekly ParentChild+ Home Visitors model for parents how to talk, read and play with their children, using Aistear [8], with its focus on child directed learning and play, as their guide. The families then continue these educational activities in their own time and at their own space. This is an intensive two-year programme, with a break over the summer months from June to the end of August in line with Irish school holidays.

In 2021, a STEM Family eLearning Framework [26] was developed to facilitate an online STEM Summer Family Learning programme to deliver multiple holistic family interventions ranging from workshops and events on STEM subjects to Virtual Robotic Coding Clubs through K-6 e-learning programmes [26, 27]. The STEM Play & Learn Programme was developed as part of this work and has since been implemented in Dublin’s Inner City for three consecutive summers in 2021, 2022 and 2023. The programme has developed throughout its lifespan using community action research [28]. This process ensures that individual programmes evolve and change according to the educational needs of the participants and the community. Action research is a powerful tool for change and improvement [29] and can be defined as an enquiry, undertaken with rigor, and understanding so as to constantly refine practice [30].

### III. STEM PLAY & LEARN PROGRAMME

STEM Play & Learn Programme is a six-week summer home learning programme targeted at families in socio-economically disadvantaged communities. Due to the diverse community of participants, the programme is designed to be delivered in a culturally responsive manner. Home Visitors receive training to equip them with the knowledge to follow appropriate customs within the home. Furthermore, as the Home Visiting team is comprised of people from diverse backgrounds, they can be matched with a family of the same culture where applicable. The programme encompasses 30-minute weekly visits from ELI’s Home Visitors, who model for the parent how STEM focused resources including storybooks, toys and crafts resources can be used to inspire scientific inquiry. Families continue the STEM activities between visits. The STEM Play & Learn Programme is based on the Community Action Research process [28] and Family e-Learning Framework [26], with adaptations to reflect the specific nature of the STEM education and Home Visiting model as shown in Figure 1. The programme combines Curriculum Planning, Home Visitor Training, Family Recruitment, Process Referrals, Intake and Allocations: Pre-Programme Survey, 6-week Programme Implementation & Data Collection, Post-Programme Survey, Data Analysis & Review.

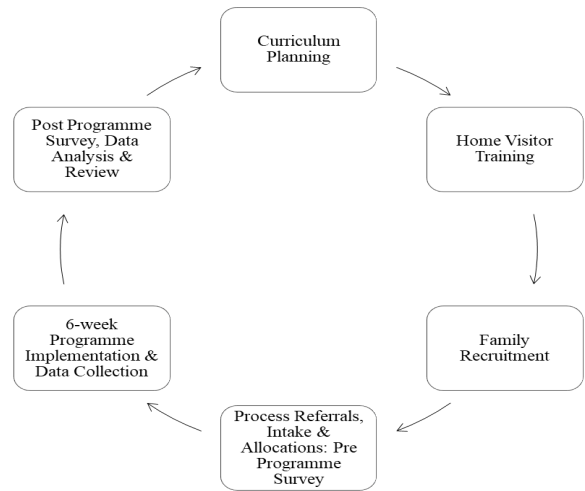


Fig 1. STEM Play & Learn Programme

**Curriculum Planning:** The first step to implement STEM Play & Learn is to structure the 6 weeks of home visits based on Aistear [8], including identifying the learning outcomes, pedagogy, home visitor upskilling needs, parental engagement and resources. The 4 Aistear Themes: Well-being; Identity and Belonging; Communicating; Exploring and Thinking, are integrated into each session. With a focus on language, thinking and exploring, open-ended play-based learning activities and educational resources are chosen to encourage children’s higher-order thinking skills, such as problem-solving, predicting, analyzing, questioning, and justifying. The central pedagogy is child-led open-ended discussions using STEM-related books (for example *Room on the Broom* by Julia Donaldson, *Snail & the Whale* by Julia Donaldson) and activities with children’s support to explore tactile sensory objects and the world around them, construct using different materials, and record their observations using writing and art materials (for example Outdoor Nature Explorer Pack, Modelling Dough set, Stickle Bricks Creative Construction Set). Activities are designed to suit children’s individual needs and connect with their experiences and interests while at the same time challenging them to extend their knowledge, refine their skills, and work with others to solve problems. The aim is for children to make sense of the things, places, and people in their world by interacting with others, playing, investigating, questioning, and forming, testing and refining ideas. Reflective practice, using planning and assessment for learning, is built into the programme [15].

**Home Visitor Training:** Building on their existing knowledge of child development, Aistear [8], and Diversity, Equality and Inclusion training, Home Visitors delivering the STEM Play & Learn Programme are provided with a 2-day specialized training. This training incorporates an overview of STEM education, what STEM learning is, the benefits of STEM learning, the programme objectives, and key strategies for STEM learning, such as, serve & return interactions and inquiry-based learning. They also receive detailed guidance on the programme activities, including Verbal Interaction Stimulus Material (VISM) guide sheets for the use of the resources. Home Visitors are required to complete reflective progress notes after each visit and take part in weekly reflective home visitor supervision, where they celebrate successes, discuss

challenges, and share best practice in delivering effective play-based STEM family learning activities.

*Recruitment of families:* Multiple methods are used to recruit families namely, referral from ELI's home visiting and family engagement programmes, along with local schools and services. Families may also self-refer hearing of the programme through social media and word of mouth [26].

*Process Referrals, Intakes and Allocations:* Referrals are processed based on need, which is based on the information from the referrer. Families with the highest need are prioritized. The family must also be living within the catchment area of Dublin 1-4. Eligible families are sent an intake link to complete, including a pre-programme questionnaire. Based on geographical area and family's needs, a Home Visitor is assigned to each family.

*Programme Implementation:* The programme is delivered over 6 weeks through 30-minute weekly home visits. Home Visitor supervision, reflection and data gathering take place throughout to monitor implementation and progress. A play-based STEM activity, which focuses on developing children's skills in numeracy, creativity, earth sciences, gross motor skills, fine motor skills, and literacy, is introduced on each visit. Numeracy activities involve but are not limited to, number matching games and puzzles to promote math concepts and sequences. Creativity and imagination are stimulated through arts and crafts activities using Play-Doh and the average household materials. Earth sciences concepts, such as the natural environment are explored through planting. Gross motor skills are developed through physical activities like action games and scavenger hunts. Concentration and focus are fostered through creative play with Lego and other construction resources like building blocks. Additionally, a variety of storybooks and activity books are introduced to facilitate inquiry-based learning and promote literacy skills, for example *Room on the Broom* by Julia Donaldson and *Snail & the Whale* by Julia Donaldson.

*Post-Programme Evaluation and Review:* The end of the programme is marked with a presentation of a certificate of completion to the family. Families are also asked to complete post-programme questionnaires to collect feedback on the programme and information on the progress of the family. The pre- and post- programme data are analyzed along with Home Visitor reflections with the findings informing programmatic review and updates. Data are analysed by calculating averages and comparing increases and decreases in numbers from the pre- and post-programme questionnaires. This is then reported using frequencies and descriptive statistics to show progress made by the families enrolled in the programme. Qualitative data are analysed by identifying recurring themes in the children and parents' responses. Examples of these are used to reinforce how the programme has impacted the families.

#### IV. METHODOLOGY

Using a community action research approach [28], which acknowledges, respects, and utilizes the expertise and experience within local families, the STEM Play and Learn Programme (Figure 1) is a cyclical process with Home Visitors, parents and children actively participating in and

evaluating the programme. The goal was to determine if the programme supported parent-child engagement, including the continuation of the learning activities between visits; parent-child satisfaction and impact; children's learning outcomes in literacy, fine motor, numeracy, language, and social-emotional skills; and parent STEM literacy, confidence, and perceptions.

Parents were invited to complete online pre- and post-programme surveys designed by ELI to evaluate their satisfaction with and experiences of the programme, its efficacy on children's developmental skills and their home learning environment. They were also asked to rate their levels of confidence and interest on a five-point scale along with questions regarding the frequency in which they engaged in home-learning reading and art activities with their child. Additionally, parents were asked about their child's developmental skills and whether they noticed any changes after the programme. Parents were also given the opportunity to provide feedback about their experience and stories about their progress in an open-ended question on the evaluations. Children were asked to complete an online post-programme survey designed by ELI. Questions included their satisfaction with and learnings from the programme. They also had the opportunity to provide feedback on how to improve the programme. Staff complete a reflection after each visit, monitoring parent and child engagement using a 3-point scale, *not engaged*, *somewhat engaged*, *very engaged*.

This research was approved by NCI's Ethics Committee. Informed consent was sought before participation. Participation in the evaluation was voluntary and was not a requirement to engage in the programme. While 83 families participated in the programme, pre- and post-programme evaluations were completed by 77 and 57 parents respectively. Likewise, 57 children completed the post-programme evaluation.

#### V. RESULTS AND DISCUSSION

This section analyses the findings and discusses the efficacy of the STEM Play and Learn Programme in addressing summer learning loss by engaging families in home-learning STEM activities, improving children's STEM skills and developing parents' confidence in supporting their children's STEM learning. Efficacy is defined as the combination of 4 dimensions namely, engagement, perceived satisfaction and impact, children's learning outcomes in literacy, numeracy, language, and social-emotional development, fine motor skills along with parents' STEM literacy, confidence, and perceptions.

Data were analysed in Microsoft Excel. Qualitative data was analysed by identifying recurring themes in children and parents' responses. Descriptive statistics and frequencies are outlined in the sections below to give an understanding of the progress made by the participating families as well as the overall development of the programme.

### A. PARENT-CHILD ENGAGEMENT

Eighty-three families with children aged between 4-6 years have participated in the programme since its development with a new cohort recruited each summer. As can be seen in Table I. The number of participants has not increased significantly over the 3 years.

TABLE I. FAMILY PARTICIPATION AND RECRUITMENT

Year	2021	2022	2023	Total
No of families	29	24	30	83
Prior ELI engagement	29	13	19	61
External referrals	0	11	21	32

However, the number of families with no prior ELI engagement has increased. This may be due to the migration of particularly vulnerable families into the area and increased knowledge by families and professionals of the programme and its benefits.

Over the past three years, 334 visits have taken place with 79.64% taking place in the home, 15.56% by video, and 4.79% over the phone or outdoors. The video, phone and outdoor visits were all delivered in 2021. The average percentage of attendance and engagement in the visits, which is outlined in Table II, is used to measure participation. Attendance has improved year by year with engagement dropping initially with the resumption of in person visits but improving in 2023.

TABLE II. AVERAGE PERCENTAGE OF ATTENDANCE AND ENGAGEMENT

Cohort Year	Attendance	Parent engagement	Child engagement
2021	54%	94%	86%
2022	80%	75%	74%
2023	84%	90%	87%

Improving the home learning environment by continuing the learning activities between visits was an important element of the programme. Parents were asked about their children's engagement in reading and art activities pre- and post- programme. As illustrated in Table III, most parents reported a positive increase in the frequency these activities occurred, especially in reading with only 1.64% of parents reading with their children and 8% of children doing art activities less than once a week. While there was a decrease in daily art activities, daily accompanied reading activities rose by 6.88%.

TABLE III. AVERAGE PERCENTAGE OF FREQUENCY IN WHICH HOME LEARNING ACTIVITIES TOOK PLACE PRE- AND POST-PROGRAMME

Activity	How often does someone at home read to the child?		How often does the child paint or draw at home?	
	Pre	Post	Pre	Post
Never/Occasionally	5.19%	1.64%	10.39%	8.06%
Once a week	15.58%	16.39%	14.29%	14.52%
Several time a week	46.75%	42.62%	41.56%	48.39%
Once a day	15.58%	16.39%	20.78%	16.13%
More than once a day	16.88%	22.95%	12.99%	12.90%

A parent commented on being surprised that their child struggles with sounding out the letters of the alphabet and affirming that they will continue exploring this with them. Overall, these findings demonstrate increased parental engagement in home learning activities with their child both during and between visits.

### B. PARENT-CHILD SATISFACTION AND IMPACT

In relation to programme satisfaction, 97.78% of parents and 95.56% of their children reported enjoying taking part in the programme. One parent commented *"I found this programme amazing for my child. She loved every visit, and it helped her gain more confidence with other people. This programme couldn't of come at a better time as my child is due to start school in September and she is usually shy in preschool with teachers etc. I found [the programme] has helped her so much"*. Children indicated that their favorite aspects of the programme were learning with their parent (40.35%), reading books (50.88%) and learning with their Home Visitor/Volunteer (85.96%). One parent commented *"Our Home Visitor was a wonderful presence for my son. He really looked forward to her visits and was happy for days afterwards. He played with all the toys and is still growing his plant which, he planted together with her. He has started school with positive attitude when he had been a bit worried about it before. We cannot thank her enough"*. These results support the importance of having a parent or adult involvement in children's STEM learning [9]. Additionally, it acknowledges children's desire for their involvement. It also affirmed the importance of basing a summer programme on an appropriate play-based curriculum such as Aistear [8] and the provision of enjoyable and appropriately challenging learning experiences for young children.

### C. CHILDREN'S LEARNING OUTCOMES

On average, parents reported improvements in their children's developmental skills as illustrated in Table IV, though these varied with the cohort. The increase

complexity of family needs and in the number of participants with no prior experience with ELI may be related to the drop in outcomes in 2023. One parent noted *“my child is more interested in reading books and I would like continues teaching her to be in the wonderful world of reading”*. One child commented learning about *“different books, building different things with my lego, and putting puzzles together”*. These results show promise in children’s later development, especially in numeracy and literacy skills. It also highlights how an increase in provision in cognitive stimulation and educational resources can enhance children’s skills and improve academic outcomes [15]. It reinforces the potential of summer enrichment programmes by [2] to address the pressing issue of summer learning loss [1], particularly among low-SES children. Overall, the results suggest that the programme is effective in improving the HLE, which leads to improvements in the learning and developmental outcomes of the children involved.

TABLE IV. TABLE IV. IMPROVEMENTS IN CHILDREN’S SKILLS AS REPORTED BY PARENTS

Cohort Year	Literacy	Fine motor	Numeracy	Language	Social-emotional skills
2021	100%	87%	100%	100%	100%
2022	80%	93%	87%	80%	93%
2023	77%	81%	85%	81%	85%

#### D. PARENTS’ STEM LITERACY, CONFIDENCE AND PERCEPTIONS

Of the parents participating in the programme 25.45% reported having a STEM qualification, the others reported ‘No’ to the question. These STEM qualifications included undergraduate and post-graduate degree in maths, arts, computer sciences, and medicine. On average, parents indicated high confidence in their ability to support their child’s STEM learning at home prior to starting the programme (89.34%), with consistent results in the post-programme evaluation (90.62%). Parents also indicated a strong belief that skills were important for their child’s future in education and in their career, pre- (92.86%) and post-programme (100%). Although majority of parents didn’t have a STEM qualification themselves, they still felt strongly about the importance of STEM for their child’s future in education and in their career. One parent without a STEM qualification noted *“I think STEM skills are important, it will help my children learn better in school, and for future, it will help my children find better job and live better”*. Another parent said that these skills expand her child’s imagination. These results support other research findings [18] and recognises the significance of parental involvement in their children’s education [18]. These results highlight how the programme supports families to engage in STEM activities with their children by promoting parent’s confidence with STEM learning at home. Promoting parent’s confidence in this area is important as it increases parental involvement in their child’s learning, which has been observed by the current study.

#### E. LIMITATIONS

This study has some limitations. Due to the levels of literacy and the cultural diversity in the community, it was necessary for the evaluations to be simple in language and easy to use. As a result, bespoke surveys were used. The study used descriptive statistics and frequencies to analyse the data, future work could incorporate statistical tests to provide stronger evidence of the programme’s efficacy. It is also important to mention that prior relationships have been established with some of the families in the study, and this prior engagement may have influenced the results. Additionally, these prior relationships coupled with the self-report nature of the surveys may have led to response bias.

#### VI. CONCLUSION

This research investigated the efficacy of a 6-week STEM Summer Family Learning programme for 4-6-year-old children in a socio-economically disadvantaged community. Once a week, trained Home Visitors modelled child-directed play-based STEM activities with families encouraged to continue the activities between visits. Findings indicate that the programme was effective with a high level of engagement and satisfaction by parents and children along with an increase in home learning activities. Children’s literacy, fine motor, numeracy, language, social-emotional skills improved. Parents’ confidence in their ability to support their child’s STEM learning at home and their belief in the importance of STEM learning for their children’s future increased.

This research can contribute to the work of early years educators and parents to introduce STEM subjects to children in fun and interactive methods through home visiting. Following Aistear [8] or a similar play-based early years curriculum and a community action research methodology ensures a culturally responsive approach is taken and the needs of all participants are met, including children, parents, and staff. This involves providing adequate training for staff to deliver high-quality STEM education that is accessible to families in socio-economically disadvantaged communities. By modeling effective teaching practices and fostering parental involvement, this summer programme equips both parents and their children with the confidence, knowledge, and skills necessary to engage with STEM education.

This study is part of a larger body of work seeking to scale ELI’s home visiting and family engagement programmes across Ireland, thereby improving the knowledge of and engagement in STEM for families living in areas of socio-economic disadvantage. This research can be replicated at national level, thereby potentially enhancing the mainstreaming and extension of STEM education in disadvantaged communities with the aim of addressing the issue of summer learning loss while also introducing STEM subjects as early as kindergarten age. By adopting the STEM Play & Learn programme model, STEM initiatives can have a greater impact, particularly during the summer break when traditional school-based interventions are not available.



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